DEVELOPMENT AND VALIDATION OF AN INSTRUMENT TO ASSESS PRECOLLEGE ARABIC SPEAKING STUDENTS' ATTITUDES TOWARD SCIENCE

BY

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THESIS

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ABSTRACT

This study is part of a large-scale project focused on identifying factors that impact precollege Qatari students' interest in, and attitudes toward, science. The study details the development and validation of an instrument to assess precollege Arabic speaking students' attitudes toward science: "Arabic Speaking Students' Attitudes toward Science Survey" (ASSASS). Grounded in theories of reasoned action and planned behavior (TRAPB), the finalized 45-item instrument addresses themes that cut across many of those present among popular, extant instruments. The ASSASS was piloted with 395 grades 3 through 12 students selected from the Arab nation of Qatar. Exploratory factor analysis resulted in a six-factor empirical model with a GFI value of 0.910 and a RMSEA value of 0.0498, which suggest a moderately good model fit. These factors, identified as positive outlook toward science, negative outlook toward science, normative beliefs, intention to pursue or engage in science, school science, and perceived utility of science, do map to a good extent onto perspectives rooted in TRAPB, but diverge from the latter to suggest substantially more complex ways in which student attitudes toward science might impact their declared intentions to pursue additional studies in science or scientific related careers.

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CHAPTER I

THE PROBLEM

Introduction

Science is becoming intertwined with almost every facet of life in an increasingly science and technology-laden globalized 21st century world. It is an unfortunate reality that many students come to view science as specialized knowledge, pursued and utilized by an elite few. Science concerns everyone, both in their everyday and professional lives (Millar & Osborne, 1998). To illustrate the importance of such knowledge, Krapp and Prenzel (2011) noted that people "constantly have to make decisions which can only be considered to be reasonable if they take scientific evidence into account" (p. 28). Consider, for example, the myriad of decisions associated with healthcare that individuals have to make; these decisions are an integral component of life in modern society (Miller, 2006). In an effort to promote the ability of the populace to make such decisions, the National Research Council [NRC] (1996) strongly advocated the goal of helping all students achieve scientific literacy as a central aim for science education. However, despite such goals, studies have continued to reveal that the level of scientific literacy among adults is rather discouraging (Miller, 1998, 2006).

Krapp and Prenzel (2011) argued for the inclusion of a broader array of elements when considering scientific literacy such as: mastery of essential science concepts, an understanding of the nature of science, and a realization of the relevance of science and technology (also see, American Association for the Advancement of Science [AAAS], 1990; NRC, 1996). This broad stance on scientific literacy is emphasized by DeBoer (2000), who also noted that the ultimate goal of such an educational focus is to produce individuals who find science interesting and important, who are able to apply science to their own lives, and who can take part in the conversations regarding the role of science in society (see also Driver, Leach, Millar, & Scott, 1996). This expansion sheds light on the crucial connection between the desirability of science literacy among individuals and the importance of science to any society or nation.

"In the 21st century, advances in science and engineering . . . will to a large measure determine economic growth, quality of life, and the health and security" of all nations and the planet (National Science Board [NSB], 2001, p. 7). The significance of science and engineering is echoed in the report *Rising above the Gathering Storm* (Committee on Science Engineering and Public Policy [CSEPP], 2005; NSB, 2001), which suggests that quality of life in the United States and around the globe is largely dependent on the continued production of knowledge and innovation in science and technology. An educated, innovative, and motivated workforce is the most important resource (CSEPP, 2005) for meeting current and future demands in science, technology, engineering, and mathematics (STEM). However, evidence (e.g., US Department of Labor, 2007) suggests that the sustainability of the scientific enterprise is currently in jeopardy with a majority of students failing to engage in STEM at the post-secondary level. Shortages in enrollment within the STEM fields and the diminished production of native scientists and engineers threaten future economic growth and prosperity for any nation around the globe.

The Scientific Enterprise: An International Perspective

Issues associated with STEM fields and the health of the scientific enterprise have received increased attention within the United States (e.g., CSEPP, 2005; NSB, 2001; US Department of Labor, 2007). Many of these issues also are profoundly significant in world regions, which do not have strong histories of scientific production. This is particularly the case for Arab countries. The Arab Human Development Report (United Nations Development Programme [UNDP], 2003) specifically spoke to the current state of scientific production in

Arab countries, highlighting “a story of stagnation in . . . scientific research” (p. 23). Evidence in support of such stagnation derives from an analysis of the number of qualified workers in science and engineering fields within Arab countries. Consider that Arab countries boast merely 371 qualified scientific workers per million citizens, a figure which is significantly lower than the global rate of 979 per million. Similarly, the number of students who choose to pursue scientific disciplines in higher education is disturbingly low. For example, the World Bank (2008) reported that a mere 20% of university students in most Arab countries are enrolled in science programs. This low percentage is staggering when compared to the 47% of university students enrolled in such programs, for example, in China. Therefore it seems reasonable to infer that relatively few Arab students have developed favorable interests and attitudes, in addition to the perceived and/or actual preparedness, which would incline them in such a way to pursue science-related degrees when choosing their college majors and eventually STEM-related careers (Abd-El-Khalick & Said, 2009).

The Situation in Qatar

The current situation in Qatar correlates with common trends in other Arab countries, with only 19% of college students enrolled in science and engineering programs while 70% are enrolled in the humanities and social sciences (World Bank, 2008). These data show a desperate need for increasing Qatari student enrollment and involvement in the sciences at the college level (Abd-El-Khalick & Said, 2009). Without high and sustainable numbers of capable and scientifically educated individuals, competition due to globalization will likely inhibit progress in STEM fields in Qatar (e.g., CSEPP, 2005). While the problem is no doubt multi-faceted, it seems reasonable to infer that only a small number of Qatari students have developed favorable interests and attitudes, in addition to the perceived and/or actual preparedness, which would incline them in such a way to pursue science-related degrees and careers. As such, it seems prudent to examine the attitudes toward, and interest in, science among pre-college Qatari students with the intention of understanding these factors and areas that could be addressed in order to increase the potential for involvement with science as these students transition into college.

The prosperity of a national scientific enterprise—in Qatar as well as elsewhere—hinges on the steady supply of STEM professionals in all scientific fields and domains, which in turn hinges on the preparation of highly qualified, diverse, and motivated learners in the sciences at every stage of the academic pipeline (Galama & Hosek, 2008). Qatar has demonstrated its commitment toward this end as evidenced by the establishment of the incredibly well endowed Qatar Foundation for Education, Science and Community Development nearly 15 years ago. One of the many goals of this foundation is to build within Qatar a research culture that "encourages the pursuit of new knowledge, conducts scientific research, and develops new technologies" (Qatar Foundation, 2009). However, the extent to which investment in higher education works to advance a scientific culture of research and practice largely depends on "inputs," especially in terms of precollege school graduates who opt to pursue, and persist in their perusal of, college studies in scientific fields. Unfortunately, like other Arab nations, the current state of affairs regarding graduate enrollment within scientific disciplines in Qatar is untenable. Indeed, in the academic year 2007-08, Qatar's sole national university could not claim a single student majoring in the fields of biology, geology, or physics, and a mere 15 chemistry majors. Considering the intimate connection of science production with the viability and sustainability of flourishing nations, this situation merits considerable attention (Abd-El-Khalick & Said, 2009).

Statement of the Problem

The alarming situation described herein is undoubtedly multi-faceted. Nonetheless, it seems that by the time Qatari and Arab students reach college or are in a position to make decisions about their university major, only a small minority of them have developed the interest, attitudes, ability and/or perceived preparedness to elect pursuing a college major in the sciences. A host of factors likely underlie this disconcerting trend ranging the gamut from the cultural and social (e.g., Aikenhead & Jegede, 1999; Costa, 1995) to the educational (e.g., Bevins, Brodie, & Brodie, 2005), and the many other relevant domains therein. However, student experiences with the teaching and learning of science in precollege classrooms are particularly relevant to this state of affairs (Patrick & Yoon, 2004). Thus, understanding the situation in Qatar entails gauging precollege Qatari students' interest in, and attitudes toward science, and the ways in which such interest and attitudes change during their years of schooling, as well as investigating the relationship between these changes, if any, and the science teaching modalities prevalent in Qatari schools. Nonetheless, no rigorous or systematic research studies have explored these domains in Qatar.

Purpose

The present study is part of a large-scale project focused on identifying factors that impact precollege—specifically grades 3 through 12—"Qatari students' Interest in, and Attitudes toward, Science" (QIAS). The first step in this project was to identify a valid and reliable measure of the target construct among Qatari students. However, a thorough search of the literature indicated that no measure currently exists that would adequately serve the purposes of the larger project. First, a literature review did not produce any instrument that were specifically developed and rigorously validated for the purpose of assessing Arabic speaking students' attitudes toward science. Second, almost all of the existing (English language) instruments were designed to assess student interests and attitudes within specific grades or grade bands rather than across the elementary, middle, and high school grades. Thus, the present study details the development and validation of an instrument to assess precollege Arabic speaking students' attitudes toward science. The instrument is titled, "Arabic Speaking Students' Attitudes toward Science Survey" (ASSASS).

Significance of the Study

Early in the history of research into the influence of affective variables, educators were challenged to think more scientifically about the measurement of scientific attitudes and attitudes toward science (Noll, 1935). In an attempt to meet this goal a number of instruments have been developed over the years with the intention of accurately assessing affective variables among students. Unfortunately, few of these instruments have demonstrated exceptional internal consistency, reliability, and/or external validity (see Blalock et. al, 2008). Therefore, the development of such an instrument would be of significant interest to the research community and a contribution to the research literature. Additionally, given the student population involved in the larger project, this study is unique because of the commitment to develop and validate the instrument in Modern Standard Arabic. Currently there is not an instrument available, which has been developed with Arabic speaking students in mind. As such, the ASSASS has an enormous potential to contribute to science education research in Arab nations and inform educators and policy makers in nations, such as Qatar, where Arabic is the native language and, in many cases, the language in which science is taught and learned.

CHAPTER II

LITERATURE REVIEW

Introduction

The following review of the literature explicates the rationale for the approach taken to address the problem presented in the preceding chapter. This review is organized in a way that presents a historical perspective on both attitudes and interest research in science education, along with definitions of key terms, followed by a presentation of notable trends and correlates relevant to this topic area. Next, the review focuses on instruments, which have been used to assess students' attitudes and interests toward science, with an emphasis on their characteristics and documented criticisms. The last section of the chapter discusses the theories of reasoned action and planned behavior, and the underlying framework of the ASSASS, as well as highlights the instrument's use in science education research. While every effort was made to present a well-rounded and fair representation of the literature, it should be noted that the author is not fluent in Arabic, and as a result literature that is not available in English was not accessible.

Focus on Affective Variables

The focus on student interest and attitudes in the sciences derive from the well-established relationship between these affective variables and precollege students' learning and achievement (Ainley, Hidi, & Berndorff, 2002; Hidi, 1990; Tobias, 1994) particularly in science (e.g., Chang & Cheng, 2008; Laukenmann, Bleicher, Fu, Gläser-Zikuda, Mayring, & von Rhöneck, 2003; Weinburgh, 1995). Additional studies (e.g., Borget & Gilroy, 1994, Calabrese-Barton & Basu, 2007; Lavonen, et al., 2008; Mason & Kahle, 1989) have reported a relationship between such affective factors and decisions to pursue scientific studies, as well as choice of future careers.

Previous studies have reported a decline in students' attitude toward science as they approach secondary school (Farenga & Joyce, 1998; Kelly, 1986; Pell & Jarvis, 2001; Speering & Rennie, 1996). This decrease is especially pronounced for girls (Greenfield, 1997). Similarly, concerning the vitality of the scientific enterprise, negative trends can be observed in student interest in science-related careers as they approach the post-secondary level (Schreiner & Sjøberg, 2004). These relationships were initially highlighted by Koballa (1988a) who attributed attention to attitudes and interests in science education to the belief that affective variables are as important as cognitive variables in influencing learning outcomes, career choices, and use of leisure time. Several investigators have engaged the problem of declining attitudes and interests, and the subsequent resulting undesirable outcomes, with the underlying hypothesis that attitudes help to steer school performance and career choice (e.g., Cannon & Simpson, 1985; Germann, 1988; Wyer, 2003).

Attitudes toward Science

"Attitudes toward science" is a broad phrase that can be used to encompass scientific attitudes and interests, as well as attitudes toward scientists, scientific careers, methods of teaching science, science curriculum, or the subject of science in the classroom (Blosser, 1984). This statement highlights one critical aspect of research in this arena: how is attitude defined? Researchers (e.g., Aiken & Aiken, 1969; Osborne, 2003) have expressed concerns over the absence of a clear definition within the research literature. The first step in defining attitudes toward science is the distinction from "scientific attitudes" due to the similar, and possibly confusing, wording. To clarify, scientific attitudes refer to particular approaches for solving problems, assessing ideas and information, and/or making decisions (Germann, 1988). Reflecting on the aforementioned description offered by Blosser, the next step in defining attitudes toward science is to examine previous conceptualizations.

The notion of measuring attitudes was first opined by the sociologist Thurstone (1928), who pointed out the complexity of the attitude construct. According to Simpson, Koballa, Oliver, and Crawley (1994), attitude contains affective, cognitive, and behavioral components. Many researchers, initially, seem to have related attitude in this sense to preference. Bem (1970) wrote to the preferential attribute of attitudes, that they represent our “likes and dislikes” (p. 14). Koballa and Crawley (1985) further explored this quality and connected it to science, by suggesting that attitudes toward science refer to whether a person likes or dislikes science, or has “a positive or negative feeling about science” (p. 223). This characteristic of attitudes, referred to as the evaluative component (Shrigley, Koballa, & Simpson, 1988), was thoroughly articulated by Koballa (1988a) who contended that the most important quality of the attitude concept is our favorable or unfavorable feelings toward objects, persons, groups, or any other identifiable aspects of our environment.

Expanding beyond the evaluative component, other researchers (e.g., Simpson & Troost, 1982) identified categories, which were regularly related to students’ attitudes toward science such as science self-concept, and attitudes toward the science teacher, physical environment of the science classroom, science curriculum, as well as feelings of anxiety associated with science. These factors continue to be considered variables of interest, and are included in several studies seeking to assess student attitudes toward science. The following sections present a brief review of the foci or factors (and associated trends) evident in empirical studies that examined attitudes and interest toward science.

Trends in Precollege Students' Attitudes toward Science

Attitude and achievement. A meta-analysis of 43 studies, including 638,333 students from 21 countries with ages ranging from kindergarten through college, revealed that the correlation between science attitude and achievement is consistently significant (0.2-0.3) for students in sixth through tenth grades (Willson, 1983). Kotte (1992) reported, from a sample of ten countries, that discrepancies in students' attitudes toward science widen as they move from elementary to secondary school. Kotte also noted that the sharpest change in attitudes between boys and girls occurred between the ages of 10 and 14 years. However despite these differences, Simpson and Oliver (1985) reported that female students were more highly motivated than males to achieve in science. Subsequent work (Simpson & Oliver, 1990), involving responses from approximately 4,500 students, revealed that females had consistently higher scores relating to their achievement motivation. In addition, Catsambis (1995) found that girls performed as well or better than boys according to their grades, despite the differences in their reported attitudes toward science.

The utility of science. George (2006) found in a cross-domain examination of students' attitudes toward science and their perceived utility of science that the overall trend was positive over a five-year longitudinal study. From this sample of 444 students, grades 7-11, George also noted a correlation between these variables and emphasized the importance of reiterating the practical applications of science. Catsambis (1995) argued, based on responses collected from eighth grade students, that males, more than females, possessed the attitude that science would be useful in their future. This finding is consistent with more recent work, but evidence suggests that some variation may exist between branches of science. For example, DeBacker and Nelson (2000) distributed 242 qualitative questionnaires to high school students in grades 10-12 who were enrolled in biology, accelerated chemistry, physics, or advanced placement physics. They noted, for their sample, that girls had higher scores on perceived instrumentality than did boys in biological sciences. Based on their findings, DeBacker and Nelson argued that students who choose to continue to study science beyond the required number of classes are those who perceive connections between science and their future goals.

Roles of family and peers. Studies have shown that the attitudes of the family toward science (Talton & Simpson, 1987) contribute, and even influence (Andre, Whigham, Chambers, & Hendrickson, 1999), the formation of these attitudes in students. More specifically, Schibeci (1989) noted that the attitudes of students' mothers were of particular importance. The experiences and opportunities afforded by families also are critical considerations, in terms of factors that shape students' attitudes toward science, as the degree of parental involvement has been highlighted in the research (e.g., George, 2000; George & Kaplan, 1996; Keeves, 1975). For example, Rani and Kaplan (1998) found that students' attitude scores were higher when parents are involved in their experiences, such as by visiting libraries and museums, and partaking in science activities.

Peer relationships, like familial ones, have been suggested to play a similar formative role in the attitudes and interests of pre-college students. In a study conducted by Talton and Simpson (1985), correlation of peer attitude toward science with individual attitude toward science indicated a strong positive relationship. Shrigley (1983) noted that this influence of peers on students' attitude toward science is more pervasive among adolescents.

The science self-concept. Similar to the previous discussion on the role of achievement motivation, Gardner (1975) noted that students' self-concept also relates to their attitude toward science. The notion of a science identity, or a self-science concept, can be found in early discussions pertaining to students' attitudes toward science. Shrigley, Koballa, and Simpson (1988) discussed the inclusion of "self-perception" as a component in their modern conception of attitude. Tytler, Osborne, Williams, Tytler, Clark, Tomei, et al. (2008) identified a strong connection between interest, identity, and self-efficacy in framing students' response to science. The identity construct appears to play an integral role in students' perception of science and their likelihood of selecting to pursue a science-related career.

Like the other aspects of student attitudes discussed here, the importance of the science self-concept has been reported as more specific for certain groups. Hasan (1985) claimed that perception of science ability is especially critical for students at the secondary level and has a profound effect on their attitude toward science. In addition, similar to previously discussed trends, Simpson and Oliver (1990) found that out of a sample of 4,500 students, males had consistently higher scores relating to science self-concept and attitude toward science. Interestingly, Mayberry (1998) posited that female students' self-concept, or science identity, has profound influence on their decision to pursue science.

Summary

An individual's attitudes toward science are multifaceted, involving both evaluative and affective components. These attitudes are shaped by numerous factors ranging from personal experiences to external factors, such as family and peers. Additionally, many researchers have noted characteristics (e.g., achievement and motivation), which regularly correlate with students' positive attitudes toward science. However, some researchers disagree over the importance of such characteristics and point out discrepancies regarding the relative strength of these contributing factors (e.g., George, 2006; Talton & Simpson, 1986; Talton & Simpson, 1985). Regardless, there seems to be a consensus regarding the decline of students' attitudes toward science as they progress through the precollege grade levels.

Interest in Science

Krapp and Prenzel (2011) discussed the increasingly divergent use of the term 'interest' in different contexts, including areas of empirical research. This confusion arose from the evolution of the term "interest" by researchers. To elaborate, early research employed a more colloquial use of the term as researchers investigated commonalities of interests between scientists and lay individuals (e.g., Bingman, 1967; Wynn & Bledsoe, 1967), but contemporary studies have largely drawn on the psychological meaning of the term (see Silvia, 2006).

As it pertains to attitudes toward science, the concept of interest usually represents the emotional component. For example, this may include students' "likes and dislikes" (Bem, 1970) and their "favorable or unfavorable feelings" (Koballa, 1988a). The notion of incorporating emotion is far from novel, as it was included in early models depicting students' attitudes toward science (Shrigley & Koballa, 1984). Expanding the scope of the model to include both attitudes and interests was thought to give a more complete picture of the affective domain. Krapp and Prenzel (2011) defended the inclusion of interest, in their review of the research literature, by positing the focus of such measures on specific content, either objects or domains, offers insight as to why students, or adults, engage or withdraw from certain themes or contexts. Gardner and Tamir (1989) advocate an intimate relationship between students' attitudes and interests and also clarify the connection between these terms:

> When we are interested in a particular phenomenon or activity, we are favorably inclined to attend to it and give time to it. Although frequently correlated with other attitude variables such as enjoyment, satisfaction or approval, these terms are not synonymous with interest. For example, one may enjoy a meal without displaying any interest in it. Conversely, one may fail to enjoy it, yet still display an interest by asking about the

ingredients. Similarly, one can be interested in issues (e.g., nuclear warfare, racism, child abuse) towards which one has a negative attitude. (p. 410)

Review of Existing Instruments

Characteristics

There are notable differences between existing quantitative measures of student attitudes toward science with regard to their focus, number of questions, and target age range. The degree to which existing instruments address attitude toward science ranges from those with a strong focus on an aspect, such as the Attitude toward Science in School Assessment (Germann, 1988), to the more generalized, such as the Science Attitude Inventory: Revised (Moore & Hill Foy, 1997). The range of questions contained within existing instruments varies widely with some utilizing less than 10 items (e.g., Hough & Piper, 1982) and others in excess of 200 items (e.g., Sjøberg & Schreiner, 2005). The intended target audience also varies between instruments; some are designed to target a single grade level (e.g., Hamerick & Harty, 1987) while others target a restricted grade-level range, such as middle or high school (e.g., Heikkinen, 1973; Skinner & Barcikowski, 1973).

In spite of the diversity among existing measures of student attitudes toward science, the response format typically used is very similar. The larger majority of the existing quantitative measures of student attitudes toward science have employed Likert-type scales, such as the Children's' Science Curiosity Scale (Harty & Beall, 1984) and the Simpson-Troost Attitude Questionnaire, Revised (Owen, Toepperwein, Marshall, Lichtenstein, Blalock, Liu, et al., 2008), with five possible responses ranging from strongly disagree to strongly agree. The Likert technique is intended to measure the strength of individuals' attitude (Fishbein, 1967 as cited in Germann, 1988).

Criticisms of Attitudes toward Science Instruments

Peterson and Carlson (1979) stated that “attitude research is chaotic” (p. 500), and over three decades later these words still hold true. Several researchers (e.g., Pearl, 1974; Munby, 1979) have placed the blame with inadequate instrumentation. Researchers (e.g., Krynowsky, 1988; Munby, 1983; Pearl, 1974; Ramsden, 1998) have been very critical of some extant measures of student attitudes and interests in science for lacking sound evidences in terms of validity and reliability. Munby (1979) criticized the validity and credibility of instruments seeking to quantify affective outcomes of science education, claiming that existing instruments do little to “enlist our confidence in their use” (p. 273).

Gardner (1975) identified internal consistency and uni-dimensionality as key statistical criteria for instrument development. However, despite such cautioning, Osborne, Simons, and Tytler (2009) found in their review of literature that efforts to establish instrument validity and reliability have been poor in multiple cases. In their review of instruments, Blalock et al. (2008) echoed this shortcoming and pointed out numerous cases in which instruments fail to meet the minimum standards of modern psychometric evaluation. Many of the instruments, which are still the basis for current research were developed in the 1970s and 1980s (e.g., Fraser, 1978; Germann, 1988; Moore & Sutman, 1970; Simpson & Troost, 1982). Owen et al. (2007) demonstrated the potential for re-evaluating extant instruments, by using factor analysis to refine the Simpson-Troost Attitude Questionnaire (Simpson & Troost, 1982) to a five-factor model. Such potential for refinement illustrates the merit, and necessity, of modern psychometric analyses in the instrument development process.

Related to issues of validity, critiques of extant instrument validity have been concerned with the item creation and/or selection process. Munby (1982) highlighted issues associated with the over-reliance on advisory panels for establishing face validity of an instrument, a common practice in the development of several measures of attitude and interest (e.g., Germann, 1988); emphasizing that the meanings attributed to the items by the panel members will not be the same as those attributed by the participants. Osborne et al. (2009), in an effort to circumvent such pitfalls, advocated the use of participant interviews following survey administration to examine how respondents interpreted questions and why they selected a given response.

Also relating to the content validity of an instrument, critiques of existing instruments have drawn attention to the necessity of clear conceptualization and a robust, well-articulated theoretical framework (Messick, 1989). Gardner (1975) also spoke to the need for clarity, especially as it relates to terminology. For example key terms like "scientific attitudes," should be distinguished from similar terms, such as "attitudes toward science," so as to minimize the potential for confusion and highlight the intended focus of a given framework.

Summary

The preceding review highlighted some poignant criticisms of extant measures of attitudes toward science, especially in terms of their validity and reliability. Critics emphasized the need for using high standards and adequate psychometric techniques when developing such instruments. In particular, they pointed out that instrument development should draw on well-articulated theoretical frameworks, and entail rigorous validation procedures. The above review also shows that existing instruments do not adequately meet the needs associated with assessing precollege Arabic speaking students' attitudes toward science throughout the precollege years, because (a) no instruments were specifically developed and validated for use with Arabic speaking students, and (b) no instruments were designed to cover the wide grade-level range that is targeted in the QIAS project.

Theories of Reasoned Action and Planned Behavior (TRAPB)

Researchers and educators, especially those aimed at understanding student attitudes, have been drawn to social psychological models as a means of understanding student social reality (Crawley & Koballa, 1994). The theory of reasoned action (Fishbein & Ajzen, 1975) represents a unifying and systematic conceptual framework, which can be used to explore a range of human behaviors. Originating in the health sciences, the theory has been successfully used to explain a variety of volitional behaviors (e.g., marijuana use, voting behavior) according to the review by Crawley and Koballa (1994). The model is based on the assumption that the affective, cognitive, and behavioral aspects of attitude interact in a causal and unidirectional manner (Figure 1).

Butler (1999) outlined the theory of reasoned action for use in science education research by considering existing studies, which worked with the theory. The progression of research centered on student attitudes toward science came to correspond naturally with the theory of reasoned action as specific behaviors, such as electing to take a high level science course or pursuing a science-related career, were considered desirable outcomes. Shrigley et al. (1988) suggested, in their review of the literature, that this connection arose from inconsistencies among early studies between reported attitudes and subsequent behaviors. Following their examination of the history of attitude research, the authors went so far as to include behavioral intention, citing Fishbein and Ajzen (1975), as a key component in the modern attitude concept (p. 676).

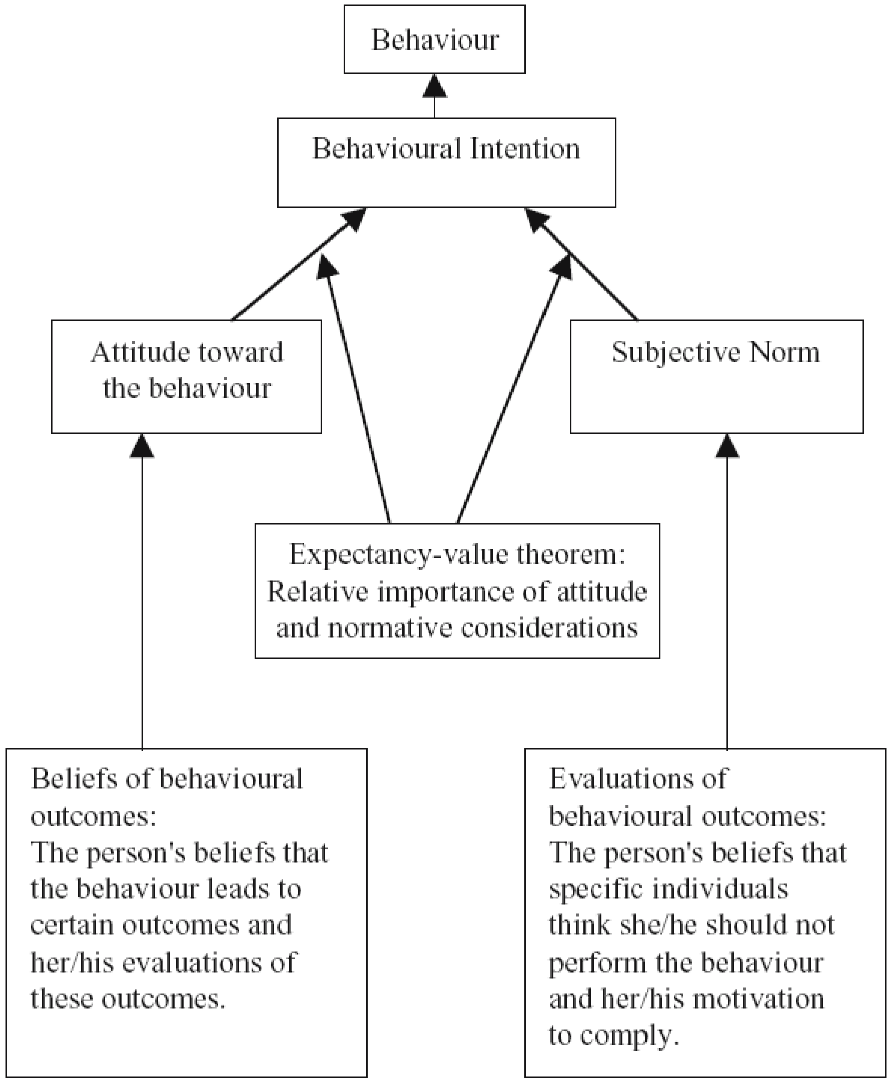

Figure 1. Factors determining a person's behavior. Arrows indicate the direction of influence (Source: Butler, 1999, p. 456; Adapted from Ajzen & Fishbein, 1980)

Empirical support for this theory comes from its successful application to several attitude and behavior studies in science education, both within the United States (e.g., Crawley & Black 1992; Crawley & Coe 1990; Koballa, 1988b) and abroad (Stead, 1985).

Based on the theory, a person's intention to perform a given behavior, rather than their attitude toward the behavior, is more closely linked to the actual behavioral performance (Fishbein & Ajzen, 1975). To elaborate, a person's behavioral intentions can be predicted from her or his beliefs, evaluations, normative beliefs, and motivation to comply. *Behavior* is defined as "an overt action under the volitional control and within the individual's capability" (Crawley & Coe, 1990, p. 463). Consequently, *behavioral intention* is characterized as a person's plan to act in a particular way and, thus, closely related to behavior. The *subjective norm* refers to an individual's perception of the "social pressures to engage or not engage in a behavior" (Crawley & Coe, 1990, p. 464). Ajzen and Fishbein (1980) contend that subjective norm is shaped by an individual's normative beliefs and their motivation to comply with those beliefs (Figure 1).

As a general rule, the more favorable the attitude and the subjective norm, and the greater the perceived control, the stronger the person's intention is to perform the behavior in question. Variance from an individual's intentions, as discussed by Ajzen and Fishbein (2005), comes from a number of studies (e.g., Bandura, 1998), which have converged on a set of variables. These variables include consequences, perceived approval of the behavior, and hindrances. To elaborate, the attitude toward the behavior may be influenced by believed consequences of engaging in the behavior, whereas the subjective norm can be shaped by how an individual believes social support will change as a result of engaging in the behavior (Crawley & Koballa, 1994).

Ajzen (1985) extended the theory of reasoned action because of criticisms regarding its limited applicability (Liska, 1984) by introducing the theory of planned behavior. The theory considers the possibility that a person may believe they do not have full control over their behavioral performance nor are they able to evaluate "how easy or difficult performance or behavior is likely to be" (Ajzen & Madden, 1986, p. 457). This consideration acknowledges that internal factors, such as a person's skills or ability, as well as external factors, like the co-operation of others or lack of resources, may influence an individual's behavioral performance.

The notable contribution of this theory is the concept of perceived behavioral control, which has a direct impact on the formation of behavioral intention that is independent of attitude and subjective norm (Crawley & Koballa, 1994). Ajzen and Madden (1986) explained that *perceived behavioral control* is "the person's belief as to how easy or difficult performance of the behavior is likely to be" (p. 457). This represents the extent to which the individual believes that performing the behavior is complicated by internal factors, such as inadequate information, skill, or ability, or external factors, such as lack of resources, opportunity, or the cooperation of others. Fishbein and Ajzen (2005) refer to their extended theoretical approach as the theories of reasoned action and planned behavior (TRAPB).

TRAPB Use in Science Education Research

As previously mentioned, social psychological models, such as the causal model outlined by TRAPB, have been championed as a means of relating attitudes reported by students with their intentions to perform a target behavior. Science education researchers employing TRAPB often have attempted to understand students' decision to engage with science (e.g., Crawley & Black, 1992; Crawley & Coe, 1990; Crawley & Koballa, 1992). Subsequently, the majority of existing research in this area has focused on factors, which contribute to students' intention to pursue elective courses in science.

Early research utilizing TRAPB with the goal of assessing student intentions focused on the relative strength of the determinants. Koballa (1988b) examined eighth grade female students' intentions to enroll in at least one elective high school physical science course. Using multiple regression analyses on behavioral intention, Koballa concluded that attitude toward the behavior carried more weight than subjective norm. Crawley and Coe (1990) furthered this line of research by exploring whether eighth grade students would take science in ninth grade if it were considered an elective course. As a result of this study the authors concluded that the relative contributions of attitude and subjective norm components to the prediction of intention to enroll in a science course in ninth grade vary depending on students' gender, ethnicity, general ability, and science ability. Crawley and Koballa (1992) expanded on this avenue of research by examining determinants that influenced a sample of 10^{th} grade students' decision to enroll in an elective high school chemistry course. In this study a sub-sample of students were asked to list the advantages and disadvantages of enrolling in chemistry, persons who would disapprove of chemistry enrollment, and factors that facilitate or inhibit enrolling in chemistry. These tasks, respectively, represent behavioral, normative, and control beliefs, which are key components of the TRAPB model. Following analysis, student responses collected were used as an empirical basis for the Chemistry Interest Questionnaire, which was then administered to the sample.

To summarize, the above review illustrates that the majority of extant studies in this domain have focused on the determinants that contribute to students' behavioral intentions regarding the pursuit of science, in the specific sense of electing to take one or more science courses in the near future. As a result, the assessment of student attitudes was a means to address the elements of the TRAPB model so that the associated intentions could be identified. However, this approach raises questions regarding the applicability and accuracy of the model in terms of using attitudes as predictive of behavioral intentions, as well as the importance of context. These queries add to a body of concerns toward the model, in general, which are presented in the following section.

Additional Considerations Regarding TRAPB

The theory of reasoned action is rooted in two significant underlying assumptions, which are separate from the issues raised in the preceding review and, which necessitate additional consideration. The first assumption, as identified by Crawley and Koballa (1994), is that actions that relate to behavioral intention do not require special skills or abilities, unique opportunities or the assistance of others, and "require only that the individual possess the motivation to perform the behaviors" (p. 38). However, it is possible that this assumption may prove invalid when dealing with students thinking about their future science studies, especially in relation to their real or perceived abilities to succeed in college science. The assumption also might not be valid in contexts outside of the United States (Stead, 1985). The second assumption is that humans are rational, in control of their behavior, and make well-informed decisions. Recall that the theory of reasoned action rests on the premise that individuals are either in complete control or have no control over their behavior, and that the subsequent modification—that is, the theory of planned behavior, was incorporated as a means of shoring up this absolute dichotomy. This latter assumption might not be applicable to the situation of younger students contemplating and/or making decisions about their immediate or long-term educational goals, such as enrolling in additional science courses in high school or pursuing a college science major some years in their distant future. Despite these criticisms and issues associated with underlying assumptions, it is unclear whether previously articulated concerns (e.g., Liska, 1984) have been fully remedied. Therefore, it should be noted that not all of the aforementioned assumptions might apply in the case of precollege students, especially in an international setting like Qatar or other Arab nations where families still have significant say in their children's academic decisions and other life choices.

TRAPB Use in ASSASS Development

Comparing the uses of the TRAPB from existing research with the approach taken in the development of the ASSASS reveals several distinct differences. Primarily, while assessments of determinants that influence students' behavioral intentions are important, the ASSASS was designed to approach assessment in a different manner than that portrayed in extant research. Consider that the review of literature in this area did not reveal any study that assessed students' behavioral intentions and then later measured the accuracy of the assessment by examining the number of students who performed the target behavior. Without such evidence, it is difficult to assess the validity of reported determinants on student behavior. This endeavor may extend beyond the scope of TRAPB, but it certainly adds an element of practicality. Conversely, the ASSASS was designed for long term, longitudinal studies which could then be coupled with other measures to meet this need. However, as a result of this design, the ASSASS may appear to sacrifice some specificity especially as it relates to student determinants, which may be specific to a given age or particular context.

In addition, all the studies outlined above focused on evaluating students' behavioral intentions on a short-term basis with data collection approximately one year before the target behavior would need to be performed. While Crawley and Black (1992), in a similar type of research, examined a slightly broader time frame in their study of 8-11th grade students' intentions to enroll in Grade 12 physics, the target time frame for behavioral predictions remained quite narrow. These results, while informative, may not generalize well over the broad age range the ASSASS is intended to serve. Recall that there is concern with the use of TRAPB with young students, especially as it relates to their perceived control over their decisions. This is furthered by the void in the literature regarding TRAPB use with younger students.

Finally, and probably most important, the TRAPB provided the theoretical framework for developing the ASSASS to help address one of the most poignant criticisms of the development of attitude instrument in science education, that is, the lack of grounding in sound theory. The

ASSASS was carefully conceptualized and designed to address aspects of the TRAPB, as well as known determinants of student behavioral intentions. Also, the use of TRAPB in the ASSASS development is distinct from literature in the field namely as a result of differing goals. Goals, such as the desire for an instrument with the capacity for use with longitudinal studies and with younger students, resulted in the TRAPB assuming a guiding role in the ASSASS development. Greater emphasis was placed on students' attitudes rather than their behavioral intentions for this instrument due to its desired function, but all components of the TRAPB model were included. Instead of empirically deriving determinants by using a sub-sample, as done in some prior studies, determinants were included through careful review of the existing literature and by the selection of ASSASS items, which will be discussed further in the following chapter.

CHAPTER III

METHOD

Purpose

The aim of this study was to develop and validate an instrument to assess precollege Arab students' attitudes toward science. The instrument described herein, titled "Arab Speaking Students' Attitudes toward Science Survey" (ASSASS, which transliterates in Arabic to 'foundation'), draws on a long history of quantitative assessments aimed at examining student attitudes toward science, science teachers, and the science curriculum (e.g., Lichtenstein et al., 2008; Moore & Hill-Foy, 1997; Simpson & Troost, 1982; Tuan et al., 2005; Tobin, 1982). As articulated in Chapter I, the development of the ASSASS focused on the following dimensions: (a) Grounding in a robust theoretical framework, (b) translation and validation in Modern Standard Arabic (MSA), and (c) generation of an instrument for use across a range of grade levels (elementary, middle, and high school grades).

Developing ASSASS

Theoretical Framework

Fishbein and Ajzen (1975) described attitude as a "learned predisposition to respond in a consistently favorable or unfavorable manner toward an attitude object" (p. 6). This description, and its emphasis on actions, guides recent research and is supported by empirical findings. This stance is supported by Allport (1968), who characterized attitude as a "state of readiness for mental and physical activity" (p. 60). In congruence with this perspective, and the empirical evidence reviewed in Chapter II, the theories of reasoned action and planned behavior (TRAPB) were selected as the guiding theoretical foundation for the development of ASSASS.

The reader is reminded that the TRAPB model is uni-dimensional, which implies that variables of interest act solely on a terminal focus: behavioral intention. As a result of this characteristic, an array of influences on student attitudes toward science can be incorporated into the model. According to this model, students' intention to perform a given behavior is determined by: (1) their attitude toward performing the behavior, which is shaped by their beliefs about the behavior; (2) their perceived approval or disapproval from important individuals, such as parents and peers; and (3) their perceived ability, which may be influenced by their assessment of the difficulty involved in performing the behavior. Also note, as previously discussed about the TRAPB model, that there may be a discrepancy between the amount of control an individual has on their choice to engage in a given behavior and the amount of control they believe to possess.

Drawing on the model presented by Fishbein and Ajzen (2005), the constructs and dimensions for ASSASS (un-shaded boxes) were defined and mapped onto major elements of TRAP (shaded boxes) as outlined in Figure 2. These dimensions and constructs were carefully selected and defined to reflect the sort of empirical evidence and conceptual discussions about student attitudes toward science evident in the research literature. It should be noted that while these dimensions and constructs are discussed in the following section, behaviors and actual behavioral controls (dashed boxes) can only be assessed through direct observation and, thus, were not addressed in the development of ASSASS.

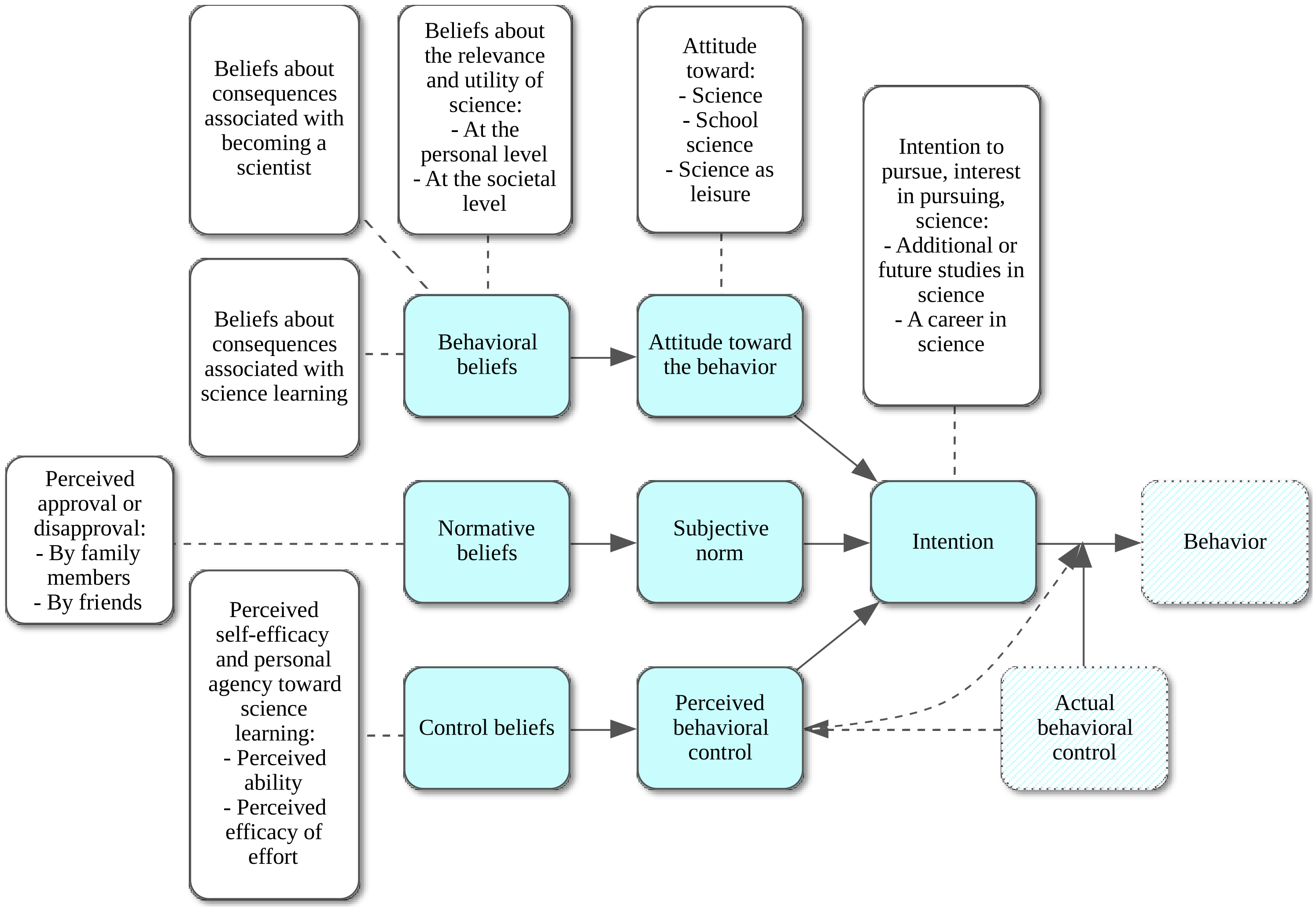

Figure 2. TRAPB Model Modified for use with the ASSASS
(Source: Adapted from Fishbein & Ajzen, 2005)

Intention is the antecedent of actual engagement with the target behavior (Ajzen & Fishbein, 2005), for this study it represents students' intention to pursue or the interest in pursuing science. *Attitude toward the behavior* is "a learned disposition to respond in a consistently favorable or unfavorable manner toward an attitude object" (Fishbein &Ajzen, 1975, p. 6). In this case, it can be interpreted as students' attitude toward different facets of science as it relates to their lives. Ajzen and Fishbein (2005) elaborate on *control beliefs* and *perceived behavioral control*:

> Beliefs concerning the presence or absence of factors that make performance of a behavior easier or more difficult . . . control beliefs lead to the perception that one has or does not have the capacity to carry out the behavior, referred to variously as self-efficacy and personal agency . . . or perceived behavioral control. (p. 193)

Control beliefs are represented on Figure 2 as perceived self-efficacy and personal agency toward science learning. For the ASSASS instrument, perceived behavioral control is assessed indirectly through the control belief input and as such it does not have any aspects listed on Figure 2. Similarly, subjective norm is also assessed through the normative belief input. *Normative beliefs* and the *subjective norm* are beliefs "that deal with the likely approval or disapproval of a behavior by friends, family members . . . and, in their totality . . . lead to perceived social pressure or subjective norm to engage or not engage in the behavior" (Ajzen & Fishbein, 2005, p. 193). For this context these beliefs are termed as perceived approval or disapproval toward engagement with science. Finally, beliefs about "the likely consequences of a behavior . . . outcome expectancies . . . or costs and benefits . . . and their associated evaluations are assumed to produce an overall positive or negative evaluation or attitude toward performing the behavior in question" are collectively referred to as *behavioral beliefs* (Ajzen & Fishbein, 2005, p. 193). As it relates to this topic area, these beliefs are about the consequences associated with engagement with science, as well as the beliefs about the benefits associated with science.

Concerns regarding theoretical framework use. In the review of literature pertaining to TRAPB use in science education research as outlined in the previous chapter, two main assumptions of the theories were presented. Recall that TRAPB operates under the assumption that humans are rational beings, able to control their own behavior, and have the freedom to make their own decisions. The second assumption at work expands this by noting that actions relating to behavioral intention cannot require special skills or abilities, unique opportunities, or the assistance of others. These assumptions are important to note as this work may be considered an empirical test of TRAPB. With that in mind, there is a distinct possibility for the audience of this study, students in grades 3-12, to fail to meet those outlined assumptions. In addition to these general concerns with the theories, there is an additional concern more specific to this audience. TRAPB was designed for and used, as it relates to science education, in the Western context. As such, it is possible that this model may be limited or ineffective in a non-western school setting.

ASSASS Item Pool

The model presented in Figure 2 served as a guide in the design process of the ASSASS instrument. The constructs mapped onto that model are representative of the theoretical dimensions and factors that were targeted in the instrument. Next, a systematic analysis of 11 published and widely used instruments aimed at assessing students' attitudes toward science was undertaken to (a) identify patterns in terms of the dimensions or constructs that are targeted by extant instruments, and (b) where appropriate, to identify potential items for use in the ASSASS. The instruments were: Attitude toward Science in School Assessment (Germann, 1988), Changes in Attitude about the Relevance of Science (Siegel & Ranney, 2003), Children's

Science Curiosity Scale (Harty & Beall, 1984), Attitudes toward Science Inventory: Modified (Weinburgh & Steele, 2000), Science Attitude Inventory: Revised (Moore & Hill Foy, 1997), Science Attitude Inventory: Modified (Nagy, 1978), Students' Motivation Toward Science Learning (Tuan, Chin, & Shieh, 2005), Science Opinion Survey (Gibson & Chase, 2002), Simpson-Troost Attitude Questionnaire: Revised (Owen, Toepperwein, Marshall, Lichtenstein, Blalock, Liu, et al., 2008), Test of Science Related Attitudes (Fraser, B. L., 1978), and Wareing Attitudes toward Science Protocol (Wareing, 1982, 1990). The analysis indicated that while some constructs (e.g., attitude toward the object—i.e., science, or the behavior—i.e., pursuing science studies) were consistently addressed in many extant instruments, other constructs (e.g., those related to control beliefs) were poorly addressed or missing altogether. Overall, the analysis affirmed the absence of a consistent or overarching theoretical framing for instruments that have been used to assess precollege students' attitudes toward science. The analysis also resulted in a pool of about 180 items, which were grouped according to similarity.

ASSASS Item Selection

A three-member panel, including the researcher, a science educator, and a measurement expert, individually evaluated the potential items, being mindful of the previously established theoretical dimensions and constructs. The purpose of this review was to eliminate redundant items and identify poorly worded or unclear items. The attention to item wording was especially important and paid close attention to the reading abilities of the younger students in the target population (3rd through 5th graders). The most common modification to items involved the simplification and clarification of compounded items (see Appendix A). For example, the item: "Much of what I learn in science classes is useful today" (Siegel & Ranney, 2003), was revised to "What I learn in science classes is useful in my everyday life." The panel met for several rounds of discussion of the item pool and associated deletions, revisions, and refinements. A small number of items also was constructed by the panel to address dimensions for the ASSASS theoretical framing, which were not addressed in other instruments. The process resulted in a pool of 74 items for the ASSASS that were aligned with the underlying theoretical framework.

Expert Review Panel

The 74-item pool resulting from the aforementioned process was distributed to an external expert review panel for evaluation. Panel members were carefully selected with an eye to cover expertise with research on precollege students' attitudes toward science, science education research, science teaching and learning, and the Qatari educational context, as well as to include science educators who were fluent in English and MSA. The panel comprised 10 experts with the following combined qualifications: 8 science education or science college faculty members (3 from national Qatari universities; 5 from international universities), 2 experts in science education research, a researcher who is considered an authority in the domain of attitudes research in science education, and 2 pre-college science education personnel from Qatari schools. Five of the panel members are fluent in both English and MSA.

Panel members were sent a package (see Appendix B) and asked to provide feedback on the ASSASS. Specifically, they were asked to provide feedback on the theoretical framework underlying the instrument, the match of each item in the pool with its respective construct or domain, the wording of each item, and the appropriateness of the language for use with students keeping in mind the youngest of the target population (i.e., grade 3 students). Panel members also were asked to suggest revisions for an item in case they identified issues with its wording, as well as suggest additional items in case they thought this was necessary.

Feedback from the expert panel was systematically analyzed. The majority of the feedback pertained to individual items. One overall panel concern, which was not directly related to the survey items, was over readability of the instrument by younger students despite an ongoing awareness of this issue through the item selection, revision, and development process. To alleviate this concern, the panel suggested that the survey items should be read aloud to third and fourth grade students.

As a result of the feedback, of the 74 original items submitted for review, 16 items (22%) were deleted, 21 items (28%) were modified, 37 items (50%) remained unchanged, and 10 new items were added. Completion of the recommended revisions, along with further consolidation of items addressing similar constructs or domains, resulted in a 60-item pilot version of the ASSASS. In addition to the survey items, the ASSASS also includes a coversheet with several items intended to collect biographical information and give additional insight into the context of students. Beyond standard demographic information, students were asked to report on the size of their home, the number and types of individuals employed by their families, as well as the types of transportation vehicles owned by the family. In the Qatari context, these latter aspects are often used by research organizations (e.g., Qatar Foundation) as indicators of socioeconomic status. Also, students were asked about the number of books present in their home, whether they had access to a computer for use at home, and if their family discussed school-related topics with them at home (see Appendix C for a copy of the instrument).

Translation to MSA

A final round of internal review took place after the recommended modifications by the review panel were made to the ASSASS items. At this point, major attention was given to the grammatical aspects of the items, as well as potential translation issues (e.g., word selection). Instrument items were translated internally by several researchers and educators fluent in both

English and Arabic. After careful deliberations and several rounds of revising the translation, the 60-item pilot version of the ASSASS was available in both English and MSA.

Pilot Study Context

The Qatari reform initiative “Education for a New Era” announced in 2002 outlined a sweeping, multi-step plan to rejuvenate the Qatari educational system (Zellman et al., 2007). The existing educational system was considered excessively rigid and outmoded. The 2002 initiative characterized the extant instruction as traditional, with an emphasis placed on rote memorization. Teachers were required to adhere to mandates from the Ministry of Education regarding curriculum and pedagogy. Effective in 2004, new curriculum standards were implemented covering Arabic, English, mathematics, and science.

Along with curricular changes, the reform mandated that new government-funded schools be established, but would not be operated by the Ministry of Education (Zellman et al., 2007). Prior to this reform, schools in Qatar could be categorized as: (1) Ministry of Education schools; (2) Independent schools; (3) International and community schools; and (4) Private schools, namely Private Arabic schools, which mainly cater to the large Arab expatriate communities residing in Qatar. These schools may selectively admit students based on certain characteristics, such as religion. Accompanying the 2002 mandate was a reorganization of existing schools, whereby all non-private schools were given “independent” status. This process began in 2004 and was completed prior to the start of the 2010-2011 academic year. Data regarding designation changes among schools were recorded along with other relevant school information for purposes of this study.

Table 1

Overview of the Target Student and School Population

School Type	Schools		Teachers		Students					
					Male		Female		Total	
	n	%	n	%	n	%	n	%	n	%
Ministry of Education	118	39.5	6169	41.2	16557	43.0	21947	57.0	38504	25.5
Private Arabic	34	11.4	822	5.5	6776	66.0	3491	34.0	10267	6.8
Independent	70	23.4	3646	24.4	21614	53.0	19168	47.0	40782	27.0
International & Community	77	25.8	4333	28.9	30748	50.0**	30749	50.0**	61497	40.7
Totals	299	100.0	14970	100.0	75695	50.1	75355	49.9	151050	100.0

*Total number of teacher, numbers of science teachers not provided by source
**Assumed percentages; actual figures not provided by source
Source: QIAS Proposal (adapted from Evaluation Institute, 2008)

Sample

A sample of 12 schools was purposively selected to represent the various types and levels of Qatari schools (i.e., Ministry of Education, independent, international and community, and private Arabic). This selection was achieved by creating a database of schools, which included information about the science classes offered (e.g., number of students in each class, number of science teachers). This approach was especially important at the secondary level due to the use of streaming in grades 11 and 12, as well as variance in offered courses between schools (e.g., a school might offer advanced chemistry but not physics). Using the intact grade as the unit of selection, a stratified random sample was drawn from the pool of all grades and grade sections in the range of grades 3–12 in the participant schools. The resulting sample included 395 students, with around 30 students per grade level (ranging from 25 to 53 students per grade level) in grades 3 through 12 (see Table 2).

Table 2

Overview of Pilot Sample Population

Grade level	Mean Age	Gender				
		Male		Female		
		n	%	n	%	N
3	8.72	28	7.59	4	1.08	32
4	9.93	22	5.96	15	4.07	37
5	10.85	23	6.23	21	5.69	44
6	11.88	22	5.96	11	2.98	33
7	12.55	24	6.50	29	7.86	53
8	13.52	28	7.59	5	1.36	33
9	14.40	0	0.00	25	6.78	25
10	15.94	15	4.07	16	4.34	31
11	16.57	23	6.23	16	4.34	39
12	17.31	20	5.42	22	5.96	42
Total		205	55.5	164	44.5	369

*Note: Gender was not reported by all students.

Of the students (44.5% female, 55.5% male), 74.4% were Qatari nationals, 18.0% non-Qatari Arabs, and 7.6% had other nationalities. The ASSASS was made available in English to non-Arabic speaking students. A total of 374 students completed the ASSASS in Arabic (94.7%) and 21 students completed the survey in English (5.3%).

Administration of the ASSASS

All participant students completed the survey in their classrooms under the supervision of their classroom teacher and a research assistant. A standard protocol for administering the survey (introducing the study, securing informed consent, giving instructions to complete the survey) was strictly followed in all classrooms. Per the recommendation of the expert review panel, the survey items were read aloud to third and fourth grade students. Individuals who read the survey to students were encouraged to read the items in a neutral tone, as to avoid conveying any cues to these younger students. Participants were allotted one 50-minute class period to complete the survey; however, the actual time for completion ranged from 35 to 45 minutes.

Following administration of the ASSASS, a random sample of roughly 4 students per grade level (40 students total, representing approximately 10% of the total number of participant students) was selected for individual exit interviews. Students were asked to comment on the survey as a whole, as well as on individual items. They were asked to (a) explain how they interpreted a subset of 15 systematically selected items, and (b) identify terms or items that were hard to understand and suggest ways to revise these terms or items. As a result, 10 students (about 3 per school level—i.e., elementary, middle, and high school) commented on their interpretation of each of the 60 items contained within the ASSASS pilot instrument.

Data Analysis

First, data collected from the pilot study were analyzed using confirmatory factor analysis against the theoretical model. In the event that this analyses did not yield meaningful results, exploratory factor analysis were to be used with the aim of uncovering trends in the pilot data or a possible underlying structure or interpretable model.

CHAPTER IV

RESULTS

Confirmatory Factor Analysis of the Theoretical Model

Confirmatory factor analysis revealed a poor fit with the previously proposed model based on the theories of reasoned action and planned behavior (TRAPB) (Figure 2). Sub-scale scores were computed for each of the theoretical domains. These domain scores were moderately to highly correlated (0.43-0.92). However, individual items correlated, moderately to strongly, with several other domain scores in addition to their own domain. On the whole, items did not correlate overly well with other items in their assigned domain.

Exploratory Factor Analysis

Exploratory factor analysis identified a strong core, with several item clusters around the core, which emerged as the empirical model. The obtained Eigenvalues did not suggest a clear number of factors to extract (Table 3). Although the first Eigenvalue was quite strong, subsequent analysis indicated that a single global factor was not sufficient. Models with between 2 and 14 factors were computed using oblique rotation. No single model seemed to be more clearly interpretable than the rest, and no model clearly reflected the theoretical design of the instrument, except for a very robust cluster of items from the intention domain. It should be noted that only 60% of the variance was explained by the theoretical model.

Confirmatory Factor Analysis of the Empirical Model

Culling through the various models, several clusters of items were identified which frequently appeared in the same factors. These six clusters are referred to as “empirical topics.” The empirical topics were compared with theoretically motivated models using confirmatory factor analysis. These models include: (a) theoretical domains, (b) theoretical sub-domains, and

Table 3

Correlation Matrix of Eigenvalues

	Eigenvalue	Proportion	Cumulative
1	14.83	24.7%	24.7%
2	3.96	6.6%	31.3%
3	2.37	3.9%	35.3%
4	1.92	3.2%	38.5%
5	1.65	2.8%	41.2%
6	1.53	2.6%	43.8%
7	1.43	2.4%	46.1%
8	1.28	2.1%	48.3%
9	1.26	2.1%	50.4%
10	1.22	2.0%	52.4%
11	1.15	1.9%	54.3%
12	1.11	1.9%	56.2%
13	1.07	1.8%	58.0%
14	1.03	1.7%	59.7%

Note: Only values greater than 1 shown.

(c) theoretical domains and sub-domains taken together (all three models were based on domains and sub-domains in Figure 2); (d) empirical topics; (e) a global factor; and (f) empirical topics orthogonal to a global factor.

Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC) were both computed as indicators of model fit to be used in the model selection process (Table 4). In general, lower AIC and BIC values indicate better model fit. This comparison ultimately revealed that the empirical topics model had better fit than the theoretically motivated models. Even though the empirical topics were strongly correlated with one another (Table 4), the empirical topics model had better fit than the model with a single global factor.

Selecting an appropriate empirical model in this case was more complex and involved than simply judging statistical output. For example, the lower AIC value associated with the global factor and topics model suggests a better model fit, but the loadings on the global factor proved not to be meaningful. These values, the AIC and BIC, do not indicate how well a model fits the data in an absolute sense, therefore it is essential that the resultant model is verified more than one statistical manner and is also determined to be sensible. In terms of further statistical verification, root-mean square error approximation (RMSEA) was computed and used as a measure of model misfit. A value of 0.0475 for the initial empirical topics model suggested the model fit is moderately good [models with RMSEA of 0.10 or more are considered to have a poor fit, while models with RMSEA of 0.05 and less are considered to be robust (Brown, 2006)]. This model selection is also supported by the computation of an additional statistic, the goodness of fit (GFI) value. This value describes how well a statistical model fits a set of observations where values closer to one are desirable. Thus, based on that criterion, the initial empirical topics model is acceptable with a GFI value of 0.915.

Table 4

Model Comparison

Model	AIC	BIC	RMSEA	GFI
Theoretical Domains	63806	64548	0.0589	0.860
Theoretical Sub-Domains	63660	64668	0.0571	0.869
Theoretical Domains and Sub-Domains	63751	64595	0.0582	0.865
Initial Empirical Topics	63051	63899	0.0475	0.915
Global Factor	64068	64771	0.0623	0.855
Global Factor and Topics	62825	63907	0.0430	0.920
Trimmed Topics			0.0496	0.908
Final Instrument			0.0498	0.910

Note: AIC and BIC are not presented for the last two models since they were computed with a reduced data set.

Factor loadings for the empirical model revealed six major item groupings (Table 5). The themes of these groupings are as follows: (a) A positive outlook on science; (b) a negative outlook on science; (c) intention or interest in pursuing science; (d) beliefs regarding the utility of science; (e) beliefs regarding science learning; and (f) normative beliefs. Conceptual review of the item groupings determined that they were intelligible and could be rationalized.

Table 5

Final Standardized Factor Loadings

Item	Positive	Negative	Intention	Utility	School	Normative
28. I am encouraged to understand and not memorize concepts in science classes	0.80					
40. I really like science	0.75					
1. I enjoy challenging science assignments	0.73					
11. Science is one of the most interesting school subjects	0.71					
33. I would enjoy working in a science-related career	0.69					
27. I like to learn more about science	0.66					
24. I look forward to the practical portions of science lessons	0.66					
15. Science is easy for me	0.64					
31. I do not feel comfortable about my ability to understand science	0.56					
14. Science classes will help prepare me for college	0.55					
18. I like to watch TV programs about science	0.54					
20. Science is useful in helping solve everyday life problems	0.45					
35. I will miss studying science in the future	0.45					
8. I am sure that I can do well on science tests	0.41					

Table 5 (continued)

Item	Positive	Negative	Intention	Utility	School	Normative
53. Science lessons are a waste of time		0.72				
59. I dislike science		0.61				
19. I cannot understand science even if I try hard		0.58				
46. Scientific work is useful only to scientists		0.56				
55. Scientists do not have enough time for fun		0.54				
42. If I could choose, I would not take any more science in school		0.50				
2. Learning science is not important for my future success		0.50				
9. Scientific discoveries do more harm than good		0.46				
10. When I do not understand a science concept, I usually give up		0.45				
17. I will not pursue a science-related career in the future		0.43				
29. I will continue studying science after I leave school			0.81			
51. I will take additional science courses in the future			0.63			
38. My family encourages me to pursue a science-related career			0.62			
7. I will study science when I get into college			0.62			
21. I will become a scientist in the future			0.58			
26. A job as a scientist would be boring			0.44			

Table 5 (continued)

Item	Positive	Negative	Intention	Utility	School	Normative
37. Knowing science can help me to make better choices about my health				0.73		
44. Knowledge of science helps me protect the environment				0.69		
47. Science will help me understand the world around me				0.68		
32. We live in a better world because of science				0.63		
49. If I work hard enough, I can learn difficult science concepts				0.51		
5. Most people should understand science because it affects their lives				0.48		
12. I really enjoy science lessons					0.74	
16. Generally my science teachers have been quite good					0.69	
4. We do a lot of interesting activities in science class					0.65	
60. My science teachers motivate me to learn science						0.61
30. My family encourages my interest in science						0.55
58. People with science-related careers have a normal family life						0.52
36. My friends like science						0.50
48. My friends do well in science						0.48

Table 6

Factor Correlations

	Positive	Negative	Intention	Utility	School
Negative	0.44				
Intention	0.80	0.26			
Utility	0.77	0.51	0.58		
School	0.82	0.36	0.58	0.66	
Normative	0.76	0.26	0.68	0.75	0.70

Item Deletion

A total of 14 items were deleted from the ASSASS instrument (Table 7). Approximately eleven items were initially suggested for removal based on their poor loadings in the empirical topics model. The other items were removed on the basis of redundancy. It should be noted that additional items could have been deleted on these premises, but they were retained at this time. This decision was rationalized by the size of the pilot study sample. Such a small pilot sample raised concerns about the basis for item deletion, ultimately some items that were believed to be of high quality were retained. In all cases of item deletion, conceptual merit was also considered and was not overshadowed by statistical deficiency.

Table 7

Items Deleted from the Pilot ASSASS

3. Scientists are highly respected
6. I consider my family's advice about my future career
13. Members of my family work in scientific careers
22. My interest in science depends on how good my teacher is
23. Much of what I learn in science classes is useful in my life outside of school
25. I can understand difficult science concepts
34. My parents influence my thinking about my education
39. I would like to do science experiments at home
43. Scientists usually like to go to work even when they have a day off
50. There is a lot of memorization in science classes
52. It is important to know science in order to get a good job
54. I enjoy science lessons when I like the specific subject I am learning
56. I have a good feeling toward science
57. I care about what my friends think when I consider future careers

Internal Consistency

In the final model, all six factors together explain 94% of the variance in the total score (Table 8). This unusually high percentage of variance explained may be the result of the high correlation in and among factors. For the individual factors, their subscale proportion is also their Cronbach's alpha value. While this does suggest that most of the scales are acceptable under the guideline of 0.7 and above, with the exception of the normative factor, it is misleading as the factors are not intended for individual use. Instead aggregate scores will be used for comparisons, and, with that intention, group means are more reliable.

Table 8

Variance Explained

Factor	Number of Items	Subscale Proportion	Squared Loadings
Positive	14	89.6%	5.47
Negative	10	80.3%	2.95
Intention	6	79.0%	2.35
Utility	6	79.1%	2.35
School	3	73.7%	1.45
Normative	5	66.4%	1.42
All Items	44	94.3%	

Note: Variance for each factor cannot be summed because factors are correlated.

Grade Level Comparison

To investigate item difficulty, especially for younger students in the sample, responses from third- and fourth-grade students were compared with those from eleventh- and twelfth-grade. This analysis yielded some items, which were arguably problematic for younger students. A few of these items were deleted, namely those items that displayed poor loadings overall. Due to the very small sample size with this pilot, especially for the grades in question, a degree of caution was displayed for the unnecessary deletion of items.

Student Interviews. The methodology section in the previous chapter included student interviews as a means of exploring, among other things, students' comprehension and interpretation of the survey items. While at least a portion of the interviews were conducted, a number of issues arose, which cast some skepticism on the validity of the responses received. The primary hindrance was the inability of the researcher to obtain audio recordings of the student interviews. This was, to a degree, anticipated as many female students in Qatar are unwilling to have their voice recorded due to cultural values. However, even the procurement of interview transcripts or detailed notes proved to be impossible. Instead, only a brief two-page summary of all interviews was received from the field interviewing staff. While this summary did not raise any major concerns, the manner in which the information contained in the summary was obtained was not as useful as originally designed and hoped for.

Summary

The Eigenvalues obtained through exploratory factor analysis identified a strong core, but due to subsequent weaker values, the analysis did not identify a clear number of factors to extract. Various models were attempted, but they did not make the data any more interpretable. Eventually, using oblique rotation, items that regularly grouped together were identified. As a result of this process, an empirical model with six major item groupings arose from the ASSASS pilot data: positive outlook on science (with factor loadings ranging from 0.41-0.80), negative outlook on science (0.43-0.72), intention to or interest in pursuing science (0.44-0.81), beliefs regarding the utility of science (0.48-0.73), beliefs regarding science learning (0.65-0.74), normative beliefs (0.48-0.61). These grouping were carefully reviewed to ensure that they were realistic and conceptually plausible in addition to simply possessing sound statistical values.

On the basis of factor loadings, in addition to other selection criteria, fourteen items were selected for deletion from the pilot version of the ASSASS. This, along with the relocation of one item to the cover, resulted in a final 45-item ASSASS instrument. The final model, following these deletions, had an acceptable GFI value of 0.910 as well as a RMSEA value of 0.0498, suggesting a moderately good fit. For the final model, all six factors together explain 94.3% of the variance in the total score. It should be noted that this unusually high percentage of variance explained is likely due to the overly interrelated nature of the issues presented in the survey. This is further supported by the strength of the first Eigenvalue obtained through exploratory factor analysis.

Analysis of the resultant factors highlights a number of interesting item groupings. The positive outlook toward science factor contained items that reflected a broad range of favorable perspectives (e.g., I like science, I do well in science class). Similarly, the negative outlooks toward science grouping contained an array of items that reflected less desirable perspectives (e.g., I do not like science, I cannot do well in science no matter how hard I try). While initially these groupings may appear as aggregates of either positively or negatively worded responses, it is important to note that even when the negative items were reversed for coding the result was two distinct groups. It is also notable that in both of these cases, based on the item groupings, there seems to be a conflation between attitudes toward the object (i.e., whether a student likes science) and their correlates (i.e., whether they are able to perform well in science).

Both the intention and the normative factors share some similarities with the theoretical model. Items within the intention factor contained statements regarding the pursuit of science or a science related career in the future. The normative factor contained items that referenced student perception of others, namely peers and family, and their interactions with science. This factor also contained items relating to individuals who encourage or motivate participation in science, including one item about the role of science teachers. The majority of the items regarding teachers and science learning comprised the school science factor. The final factor, the utility of learning science, contained items addressing important outcomes of learning science, as well as items offering reasons that others should learn science.

CHAPTER V

DISCUSSION AND CONCLUSIONS

Complexities of Assessing Students' Attitudes toward Science

As discussed in the previous chapter, analysis of the data collected during the ASSASS pilot deviated from the theoretical model, which was rooted in the theories of reasoned action and planned behavior (TRAPB). The reader is reminded of Figure 2, which illustrates the TRAPB causal model, as well as the connections to the theoretical model for the ASSASS. The model presented outlined very unique aspects and determinants that were suggested to predict student behavioral intentions. Overall, the model depicted was, in a sense, very "neat." By comparison, the data collected from the ASSASS pilot study was considerably more complex. The emergent empirical model could serve to make sense of the pilot data where the theoretical model proved inadequate. In a sense, the ASSASS data could be thought of as an empirical test of the TRAPB as it applies to predicting behavioral intentions related to medium and long-term goals.

The initial selection of TRAPB as the theoretical foundation of the ASSASS was due to its prominent position among current research into affective variables. As explicated in Chapter 2, a group of researchers has adopted the theory of reasoned action based on successes demonstrated in studies involving simple volitional decisions. In science education, this adoption has translated, for example, into studies examining determinants that influence students' intentions to pursue elective science courses. It is important to reiterate that the review of the literature showed that extant studies have failed to follow up on the declaration of such intentions by assessing actual student engagement with the target behavior. In addition, the review of literature in this field revealed significant differences between prior use of the TRAPB and the aims of the ASSASS instrument.

The review of TRAPB literature, including issues related to underlying assumptions, revealed a number of potential concerns about using the TRAPB within the context of an instrument like ASSASS. These problems are most notable as they relate to the specific design goals of the ASSASS (i.e., use in longitudinal studies), as well as concerns about ASSASS use with younger students and in an international context. Awareness of these concerns impacted the design process of the instrument, which attempted to ameliorate some of these concerns. Namely, the systematic review of existing attitude instruments to create a robust item pool and the vigorous item selection process were intended to adequately represent the domains implicated by the TRAPB as important for predicting intentional behaviors, while also being mindful of a wide age range in terms of participant students, as well as their cultural context. However, despite these considerations, results from the pilot study were not interpretable using the theoretical model. It seems likely that some of the assumptions upon which TRAPB rests were not applicable to students in the Qatari context, or that other distinctions in the ASSASS approach previously highlighted resulted in results, which were not aligned with the theory. Of course, it does not escape the researcher that the issue might as well be with the ASSASS design and/or items themselves. The latter possibility, however, is not likely given that ASSASS employed items and addressed domains and determinants, some of which were used in previous studies to successfully predict behavioral intentions to pursue short-term goals related to selecting elective science courses. If anything, the ASSASS was more comprehensive in its alignment with the various dimensions deemed relevant by the TRAPB.

Approaching the pilot data using the theoretical model to interpret the results (i.e., confirmatory factor analysis) revealed a scenario whereby ASSASS item scores tended to correlate strongly with their own domain, as well as with other domain scores. Furthermore, individual items, in general, correlated poorly with other items in their own domain. These correlations complicated subsequent analysis and suggested that many of the target constructs and domains seemed to have been tightly intertwined from the perspective of participant students. These complexities led to the conclusion that the relatively simple theoretical model in use would not be able to adequately account for these pilot data. One could argue that these, with some caution, provide some empirical test for the theory at hand.

Through exploratory factor analysis an empirical model emerged, and after refinement depicted several notable relationships and interesting item groupings in the instrument. The finalized ASSASS model contains six major item groupings: (a) positive outlook on science, (b) negative outlook on science, (c) intention or interest in pursuing science, (d) beliefs regarding the utility of science, (e) beliefs regarding science learning, and (f) normative beliefs. An examination of Figure 2 reveals a notable finding: two of the empirical groups are consistent with those associated with the TRAPB theoretical model. In particular the empirical “intention or interest in pursuing science” and “normative beliefs” item groupings map onto the TRAPB dimensions *intention* and *normative beliefs* respectively. The intention grouping was relatively straightforward including items that asked students if they intended to pursue science or a science related career in the future. The normative factor contained items, which referenced student perceptions of others, namely peers and family, and their interactions with science. This grouping is consistent with the literature reviewed in chapter 2 as both groups are believed to play a formative role in the development of students’ attitudes toward, and interests in, science. Interestingly, this factor also contained items relating to individuals who encouraged or motivated students' participation in science, including one item pertaining to the role of the teacher. The majority of the items regarding teachers and science learning comprised the school science factor. The presence of this factor affirms that the ideas of school science and the importance of the science teacher are present in the minds of students.

Additionally, "beliefs regarding the utility of science" and "beliefs regarding science learning" could be thought of as relevant subcomponents of the TRAPB *behavioral beliefs* component. The utility of learning science factor contained items addressing important outcomes of learning science, as well as items offering reasons about why others should learn science. Items regarding the utility of science, such as those pertaining to more specific reasons to learn science (e.g., making good decisions about health), were grouped with items that related to effort and science learning. The grouping of items composing this factor is quite unique, but the notion that such a factor exists does suggest that students do understand the usefulness, and even benefits, of science and science education. Curiously, students seem to identify with reasons to learn science and that these reasons are apparently good enough to merit effort, but their responses group independently from the positive outlook on science category.

The remaining two empirical item groupings seemed to, if you will, 'crossover' several of the TRAPB elements: Both the positive and negative outlook groupings contained items that cut across the *intention*, *attitude toward the behavior*, *control beliefs*, and *behavioral beliefs* of the TRAPB; the difference is that the groupings point in different directions. The positive outlook toward science factor contained items, which reflected a broad range of favorable perspectives toward varying aspects of science (e.g., I like science, I do well in science class). Similarly, the negative outlooks toward science grouping contained an array of items that reflected less desirable perspectives (e.g., I do not like science, I cannot do well in science no matter how hard I try). As noted above, closer examination reveals that items in these two factors are representative of behavioral beliefs, attitudes toward the behavior, and control beliefs from the theoretical model. In some significant sense, aspects that the are neatly segregated in the model seem to be closely intertwined in student minds. Specifically, students did not seem to separate liking (or disliking) science, from perceiving they are able to do well (or not so well) in science, from believing that science (or is not) relevant to their future. Of course, the design of the present study does not allow determining whether these results are due to issues with the theoretical model itself with the extent to which ASSASS is capable to accessing the posited constructs (if, indeed, they are distinct in student minds) in the context at hand. What is crucial to note though, is that if these groupings are indeed reflective of some synthetic or integrated construct in student minds, they might as well prove to serve as strong predictors of students' intentional behaviors and/or actual behaviors in relation to pursuing additional science studies.

Overall, the empirical model is very promising as it sheds light on the complexities of student attitudes, interests, and intentions as they relate to science. This model does share similarities with the theoretical TRAPB-based model, which can be clearly observed in the intention and normative beliefs factors. The positive and negative outlooks toward science factors also cut across multiple aspects of the theoretical model. The seeming conflation evident in student responses with regard to these two factors, suggests that behavioral beliefs, control beliefs, and attitudes toward the behavior, which are distinct in the TRAPB model, are muddled within these factors. By extension, it is conceivable that the simplistic causal model outlined by the TRAPB is not as distinct and intact within the minds of students as is conveyed in Figure 2.

The Role of Culture and Context

In chapter 3 it was suggested that the use of TRAPB as a theoretical framework for the design of the ASSASS could be considered an empirical test of the model. While the results obtained from the pilot led to the consideration of an alternate model, there are a number of prevailing questions as to the reason for the lack of fit between the model that guided the design of the ASSASS and the empirical data collected in the study. Certainly, this lack of fit could highlight an issue with complex data in the TRAPB model as alluded to in the previous section. By comparison the TRAPB model is very simple, with clearly defined determinants that work toward a single end. The data obtained from the pilot study; however, seemed more heavily intertwined. In chapter 3, assumptions regarding the TRAPB model as well as its use in the Qatari context were outlined. These assumptions, namely that students' in this case would need to be capable of making rational decisions regarding their future science involvement. This capability extends to both their actual freedom of choice as well as their perceived freedom, in addition to the mental faculties necessary of such decisions. It is plausible that the dissonance observed could be in part due to the context of the pilot population, namely that the pilot context deviates from the population and culture for which this model was designed.

Qatar possesses a number of cultural attributes that may have confounded the extent to which existing research, largely conducted in western cultures, generalizes to Middle Eastern cultures. This consideration is particularly relevant regarding different conceptions of gender and gender roles. To this end, it is probable that many female Qatari students operate under traditional, male dominant gender roles common to their culture. These roles, especially if reinforced by family members, may reduce the likelihood for female students to pursue or engage with science regardless of their personal intentions. Such an influence would undoubtedly call to question the amount of control these students have over their own behavior, which is vital to the TRAPB model.

The notion of gender as it relates to affective aspects of science and preference has recently been discussed suggesting some differences from the literature previously reviewed (see Haste, 2004). Largely, this work contends that females, despite being disadvantaged by stereotypes and prevailing traditional views, may hold more interest in certain science domains. While Haste's work contrasts a number of published works, it is conceivable that such a phenomena could be at work in Qatar. To better understand the extent of cultural influence, as well as the other remaining and emerging questions, further research is required.

Implications for Future Research

A multitude of issues emerged as a result of the development and validation of the ASSASS. To further explore these issues, implementation of the ASSASS and the collection of additional data is necessary. The administration of the ASSASS to large numbers of students will provide for the continued refinement of the instrument on several fronts. Furthermore, the empirical model that emerged from the pilot study would greatly benefit from additional data and subsequent analyses.

One key issue that demands attention is the validity and reliability of the refined instrument, especially across grade levels and languages. Namely, there were a small number of items retained from the pilot version despite some concern about their use with younger students. It is possible that future evidence may merit the modification or deletion of these items. Similarly, additional data collection at each grade level will afford a sense of individual item performance as these interact with specific age or grade levels and/or ranges. This may prove to be especially meaningful in tracking changes in student attitudes and interests over time.

One of the major goals behind the development of the ASSASS was the production of an instrument in Modern Standard Arabic (MSA). Through a rigorous process this goal was met; however, there are still many benefits that can result from the completion of additional surveys in both MSA and English. Namely, further usage is essential to both ensure the accuracy of the translation and the appropriate contextual use of the terms within the instrument. Due to the richness of the Arabic language there can be some difficulty in matching an English term with the appropriate term in Arabic, which is then further compounded by the prevalence of region specific dialects and preferences. Therefore, additional data in both languages is essential to increase the symmetry between the English and MSA versions. It is also possible that through continued refinement of the instrument terminology, along with an larger data set, for some degree of cross-cultural validity of the ASSASS to be established.

Distinct from the previous issues presented, the empirical model proposed from the ASSASS pilot data would benefit from further research. It is possible that a larger pool of data would confirm the item groupings present in the current empirical model and speak to the validity of the model. If this is the case, subsequent use of the instrument will grant the opportunity to test the predictive power of the model and explore the meaning of students' responses to the ASSASS. For example, based on the model presented here, it seems reasonable to explore whether scores relating to positive outlooks toward science positively correlate with intentions to participate and pursue science, while also negatively correlating with the negative outlooks toward science grouping.

Limitations

The main limitation of the ASSASS pilot study pertained to the sample size. While significant efforts were made to draw a representative sample, sub-sample comparisons reaffirmed the need for additional data. To be more specific, the sample was limited in the number of students per grade level and the number of surveys completed in English. It should be noted that this occurrence was, to a degree expected, due to the nature of the pilot study. Additional data collection is anticipated. Additional iterations of the survey should afford information on individual item performance, specifically across grade levels. Additional data should also provide information regarding both the English and Arabic versions of the ASSASS instrument in terms of language usage and student interpretation.

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APPENDIX A: ASSASS Initial Item Pool

Table A.1 *Sources*[1] *for the Items included in the Item Pool for the Arabic Speaking Students' Attitudes toward Science Survey (ASSASS) Instrument*[2]

Item	Item source(s)	Modified item
I would like to continue studying science after I leave school		
If it were up to me, I would not take any more science classes		
I would like to take another science course	SOS	
I will be glad when I am done studying science	SOS	✓
I will miss taking science courses in the future	SOS	
I would be wasting my time if I took more science courses	SOS	
A job as a scientist would be interesting	SOS, TOSRA	
A job as a scientist would be boring	SOS, TOSRA	
I would like to become a scientist in the future		
I would enjoy being a scientist	STAQ-R	
I do not want to be a scientist	SAI_II	
I have a good feeling toward science	mATSI	
I feel tense when someone talks to me about science	mATSI	
I really like science	STAQ-R	
I dislike science		
Science is fun	ATSS	
Science is boring	ATSS	
Science is one of my favorite subjects	mATSI	
The worst school subject is science	WASP	
I look forward to science lessons	SOS, TOSRA	
I dislike science lessons	SOS, TOSRA	
Science is one of the most interesting school subjects	SOS, TOSRA	
Topics in science class are boring	WASP	
Science lessons are a waste of time	SOS, TOSRA	
I really enjoy science ~~courses~~ lessons	SOS, TOSRA	✓
Science lessons are fun	SOS, TOSRA	
Science lessons bore me	SOS, WASP TOSRA	
I would like to learn more about science	ATSS, SOS	
I would like to do some extra ~~or un-assigned~~ reading in science	mATSI	✓
I dislike reading books about science during my holidays	TOSRA	
I like to watch television programs about science	CSCS	
I get bored when watching science programs on TV at home	TOSRA	
I would like to do science experiments at home	TOSRA	
I am sure that I can do well on science tests	SMTSL	
I do not do very well in science	mATSI	
Science is easy for me	mATSI	

[1]Source abbreviations are explicated below.
[2]The researchers wrote the items that do not show a source.

Table A.1 (*continued*)

Item	Item source(s)	Modified item
Whether the science content is difficult or easy, I am sure that I can understand it	SMTSL	
I enjoy ~~like~~ the challenge of science assignments	mATSI	✓
No matter how hard I try, I cannot understand science	mATSI	
I do not try to learn science content that I find difficult		
When I do not understand a science concept, I find someone who can help me ~~relevant resources that will help me~~	SMTSL	✓
If I work hard enough, I can learn difficult science concepts		
My family encourages my interest in science	WASP	
Members of my family work in scientific careers	WASP	
Most of my friends do well in science	STAQ-R	
My friends like science	STAQ-R	
Scientists can have a normal family life	TOSRA	
Scientists do not have enough time for their families	SAI_II_mod	
Scientists are weird people.		
A scientist looks like anyone else you might meet		
Scientists do not have enough time for fun	SAI_II_mod	
Scientists have hobbies just like everyone else		
Scientists usually like to go to ~~their laboratories~~ work when they have a day off	TOSRA	✓
Science teachers make science interesting	mATSI	
Generally my science teachers have been quite good	WASP	
We do a lot of ~~fun~~ interesting activities in science class	STAQ-R	✓
There is too much to memorize in science classes	WASP	
I am encouraged to understand the concepts in science classes		
Science helps people everywhere	WASP	
We have a better world to live in because of science	WASP	
Scientific discoveries do more harm than good ~~are doing more harm than good~~	TOSRA	✓
Scientific work is useful only to scientists	SAI_II	
~~People~~ Most people should ~~must~~ understand science because it affects their lives	SAI_II	✓
~~Much of what~~ What I learn in science classes is useful in my everyday life ~~today~~	CARS	✓
Science is useful in helping solve ~~to solve the problems of everyday life~~ everyday like problems	mATSI	✓
Science ~~experiments~~ can help me to better understand the world	CARS	✓
Science will help me understand the world around me ~~more about world-wide problems~~	CARS	✓
Science has nothing to do with my life outside of school	CARS	
Knowing science can help me to make better choices regarding my health ~~about medical issues~~	CARS	✓

Table A.1 (*continued*)

Item	Item source(s)	Modified item
Knowledge of science ~~will help~~ helps me protect the environment	CARS	✓
Science can help me make better decisions about what I buy	CARS	
It is important to know science in order to get a good job	mATSI	
Science ~~class~~ classes will help prepare me for college	CARS	✓
Learning science is not important for my future success	CARS	

Source abbreviations

ATSS = Attitude toward Science in School Assessment (Germann, 1988)
CARS = Changes in Attitude about the Relevance of Science (Siegel & Ranney, 2003)
CSCS = Children's Science Curiosity Scale (Harty & Beall, 1984)
mATSI = Attitudes Toward Science Inventory, Modified (Weinburgh & Steele, 2000)
SAI_II = Science Attitude Inventory: Revised (Moore & Hill Foy, 1997)
SAI_II_mod = Science Attitude Inventory: Modified (Nagy, 1978)
SMTSL = Students' Motivation Toward Science Learning (Tuan, Chin, & Shieh, 2005)
SOS = Science Opinion Survey (Gibson & Chase, 2002)
STAQ-R = Simpson-Troost Attitude Questionnaire, Revised (Owen, Toepperwein, Marshall, Lichtenstein, Blalock, Liu, et al., 2008)
TOSRA = Test of Science Related Attitudes (Fraser, B. L., 1978)
WASP = Wareing Attitudes toward Science Protocol (Wareing, 1982, 1990)

APPENDIX B: Packet Distributed to Advisory Panel

QATARI STUDENTS' INTEREST IN, AND ATTITUDES TOWARD, SCIENCE (QIAS) PROJECT

Eliciting Feedback on, and Establishing Content Validity of, Items for the Instrument
Arab Speaking Students' Attitudes toward Science (ASSAS)

March 15, 2011

Dear ,

I want to take this opportunity to thank you again for your willingness to serve as a Member of the International Advisory Board for the Qatari Students' Interest in, and Attitudes toward Science (QIAS) project funded by the Qatar Foundation.

Drawing on a national probability sample of precollege students, science teachers, and schools in Qatar, QIAS aims to (a) assess students' interest in, and attitudes toward, science, and the ways in which these variables change during the school years; (b) identify factors that impact students' interest and attitudes, including their dispositions toward pursuing future science studies and scientifically-based careers; (c) characterize the prevailing modalities of science teaching in the various types of precollege Qatari schools; and (d) examine the relationship between students' interest and attitudes, and their science learning experiences.

A crucial aspect of QIAS lies with the measurement of participant students' attitudes toward science and their interest in pursuing science studies and/or careers. Our target population includes students in all Qatari schools enrolled in grades 3 through 12. Given the target population and the context of the study, it is crucial that we have access to an instrument that (a) is clearly grounded in theory; (b) is validated for use with students drawn from the target population; (c) has equally valid and reliable English and Arabic versions; and (d) is accessible to participant students in grades 3 through 12 to ensure consistency in measuring the target domains and constructs. Currently, there are no Arabic language instruments that meet these criteria. Additionally, based on an extensive review of the literature, we have determined that none of the currently existing English language instruments would, on its own, serve as the English version, which could be used to generate and validate an Arabic version.

Thus, building on extant instruments, we decided to build our own instrument: "Arabic Speaking Students' Attitudes toward Science" (ASSAS). Our plan is to develop the instrument in English, create an equivalent Arabic version, and then validate both versions of the instrument with a sample of Qatari students that is representative of the target population. **We are writing to elicit your feedback on, and ask for your help in establishing the content validity of, a pool of English language items that we will eventually use to build ASSAS.** The greater majority of these items were taken as is from pervious instruments, others were adopted from the same instruments with slight modification, and the QIAS team authored a few other items. Table 1 (see Appendix A) presents a full listing of the items showing the instrument(s) from which each was taken and whether an item was modified or not.

The ultimate aim associated with measuring students' attitude toward science is predicting their future behavior (Koballa, 1988), in this case, their intentional behaviors to pursue science in the form of additional/future studies and/or a scientific career. Toward that end, we are grounding our instrument in the most recent revision of the theory of reasoned action (Ajzen & Fishbein, 1970, 1980; Fishbein & Ajzen, 1975), namely, the theories of reasoned action and planned behavior (TRAPB) (Ajzen & Fishbein, 2005).

Figure 1 (Appendix B) provides an overview of the major elements of TRAPB (shaded light blue boxes), as well as ways in which the domains and constructs of ASSAS (un-shaded boxes) map onto the elements of the theory. Table 2 (Appendix C) provides brief definitions of the elements of TRAPB that are amenable to measurement through a self-report paper-and-pencil instrument (e.g., behaviors and actual behavioral controls can only be assessed through direct observation), and the associated domains and constructs that the ASSAS instrument aims to measure. **If you have any comments on this theoretical framework, or the ways in which ASSAS domains and constructs map onto the framework, please provide your comments on the last page of this document** (p. 16).

At this point in the process, **we would very much appreciate your help with providing feedback on the ASSAS domains and constructs, as well as the associated pool of items. Please provide your feedback by typing directly into the tables provided on pages 4 through 9**. Save your feedback in the same file and e-mail your file to fouad@illinois.edu. We would appreciate it if you follow the following instructions as you complete the tables on pages 4–9:

1. For each sub-domain or sub-construct, indicate whether you think the sub-domain or sub-construct is important or not;

2. Use the space provided under the last column in the table to indicate whether you think additional domains, constructs, sub-domains, or sub-constructs ought to be added to the instrument;

3. For each item under a sub-domain or sub-construct, indicate whether you think
    a. The item provides for a good or a poor fit with the corresponding sub-domain or sub-construct;
    b. Whether the wording of the item is good or poor; and/or
    c. Whether the item need to be discarded altogether;

4. If you think the wording of an item is poor, please provide suggested revisions in the space provided under the last column in the table;

5. For each sub-domain or sub-construct, insert any additional items that you deem necessary or that you think would enhance the measurement of this sub-domain or sub-construct;

6. Use the space provided under the last column in the table to insert any questions, ideas, or comments that you have in relation to any aspects of the associated domains, constructs, sub-domains, sub-constructs, and/or items.

As you complete the tables, please keep the following in mind:

1. Not all the items that appear in the tables on pages 4–9 will end up on the ASSAS instrument. We are eliciting feedback on a pool of item. We do realize that some of the items are redundant in terms of what they aim to assess. Our aim is to end up with a total of 50–60 items, which are short, straightforward, and easy to understand given that the instrument is geared toward students in grades 3 through 12;

2. The term "construct" refers to a well-defined psychological construct, such as "attitude toward science" or "perceived self-efficacy toward science learning." In contrast, the term "domain" refers to a collection of beliefs or perceptions, which might or might not have an underlying psychological construct, such as "perceived approval or disapproval of engagement with science by peers"; and

3. We estimate that the time burden associated with completing this task to be around 2–3 hours. We really appreciate you taking the time out of your busy schedule and lending your expertise to help with this task.

Should you have any questions or need additional information, please do not hesitate to e-mail or call us:

Fouad Abd-El-Khalick: fouad@illinois.edu; +1 (217) 390-5145
Ziad Said: ziad.said@cna-qatar.edu.qa; +974 4495 2348

We want to thank you again for your help with this project, and look forward to receiving your feedback.

Sincerely,

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Department of Curriculum and Instruction
University of Illinois at Urbana-Champaign
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Domain or construct and relation to TRPB	Sub-domain or sub-construct	Important domain or construct?		Item	Item fit with domain or construct?		Wording of item?		Suggested revisions to item; or indicate if item is to be discarded (or other notes about the item, domain, or construct).
		No	Yes		Poor	Good	Poor	Good	
(I) Intention: Intention to pursue, interest in pursuing, science	(I.a) Additional or future studies in science			1. I would like to continue studying science after I leave school					
				2. If it were up to me, I would not take any more science classes					
				3. I would like to take another science course					
				4. I will be glad when I am done studying science					
				5. I will miss taking science courses in the future					
				6. I would be wasting my time if I took more science courses					
				Use the rows below to insert additional items if deemed necessary					
	(I.b) A career in science			7. A job as a scientist would be interesting					
				8. A job as a scientist would be boring					
				9. I would like to become a scientist in the future					
				10. I would enjoy being a scientist					
				11. I do not want to be a scientist					
				Use the rows below to insert additional items if deemed necessary					

Domain or construct and relation to TRPB	Sub-domain or sub-construct	Important domain or construct?		Item	Item fit with domain or construct?		Wording of item?		Suggested revisions to item; or indicate if item is to be discarded (or other notes about the item, domain, or construct).
		No	Yes		Poor	Good	Poor	Good	
(II) Attitude toward the behavior	(II.a) Attitude toward science			12. I have a good feeling toward science					
				13. I feel tense when someone talks to me about science					
				14. I really like science					
				15. I dislike science					
				16. Science is fun					
				17. Science is boring					
				Use the rows below to insert additional items if deemed necessary					
	(II.b) Attitude toward school science			18. Science is one of my favorite subjects					
				19. The worst school subject is science					
				20. I look forward to science lessons					
				21. I dislike science lessons					
				22. Science is one of the most interesting school subjects					
				23. Topics in science class are boring					
				24. Science lessons are a waste of time					
				25. I really enjoy science lessons					
				26. Science lessons are fun					
				27. Science lessons bore me					
				28. I would like to learn more about science					
				Use the rows below to insert additional items if deemed necessary					
	(II.c) Attitude toward science as leisure			29. I would like to do some extra reading in science					
				30. I dislike reading books about science during my holidays					
				31. I like to watch television programs about science					
				32. I get bored when watching science programs on TV at home					
				33. I would like to do science experiments at home					
				Use the rows below to insert additional items if deemed necessary					

Domain or construct and relation to TRPB	Sub-domain or sub-construct	Important domain or construct?		Item	Item fit with domain or construct?		Wording of item?		Suggested revisions to item; or indicate if item is to be discarded (or other notes about the item, domain, or construct).
		No	Yes		Poor	Good	Poor	Good	
(III) Control beliefs: Perceived self-efficacy and personal agency toward science learning	(III.a) Perceived ability toward learning science			34. I am sure that I can do well on science tests					
				35. I do not do very well in science					
				36. Science is easy for me					
				37. Whether the science content is difficult or easy, I am sure that I can understand it					
				38. I enjoy the challenge of science assignments					
				Use the rows below to insert additional items if deemed necessary					
	(III.b) Perceived efficacy of effort toward learning science			39. No matter how hard I try, I cannot understand science					
				40. I do not try to learn science content that I find difficult					
				41. When I do not understand a science concept, I find someone who can help me					
				42. If I work hard enough, I can learn difficult science concepts					
				Use the rows below to insert additional items if deemed necessary					

Domain or construct and relation to TRPB	Sub-domain or sub-construct	Important domain or construct?		Item	Item fit with domain or construct?		Wording of item?		Suggested revisions to item; or indicate if item is to be discarded (or other notes about the item, domain, or construct).
		No	Yes		Poor	Good	Poor	Good	
(IV) Normative beliefs: Perceived approval or disapproval	(IV.a) By family members			43. My family encourages my interest in science					
				44. Members of my family work in scientific careers					
				Use the rows below to insert additional items if deemed necessary					
	(IV.b) By friends			45. Most of my friends do well in science					
				46. My friends like science					
				Use the rows below to insert additional items if deemed necessary					

Domain or construct and relation to TRPB	Sub-domain or sub-construct	Important domain or construct?		Item	Item fit with domain or construct?		Wording of item?		Suggested revisions to item; or indicate if item is to be discarded (or other notes about the item, domain, or construct).
		No	Yes		Poor	Good	Poor	Good	
(V) Behavioral beliefs: Perceived consequen-ces of engaging with science	(V.a) Beliefs about consequences associated with becoming a scientist			47. Scientists can have a normal family life					
				48. Scientists do not have enough time for their families					
				49. Scientists are weird people					
				50. A scientist looks like anyone else you might meet					
				51. Scientists do not have enough time for fun					
				52. Scientists have hobbies just like everyone else					
				53. Scientists usually like to go to work when they have a day off					
				Use the rows below to insert additional items if deemed necessary					
	(V.b) Beliefs about consequences associated with science learning			54. Science teachers make science interesting					
				55. Generally my science teachers have been quite good					
				56. We do a lot of interesting activities in science class					
				57. There is too much to memorize in science classes					
				58. I am encouraged to understand the concepts in science classes					
				Use the rows below to insert additional items if deemed necessary					

Domain or construct and relation to TRPB	Sub-domain or sub-construct	Important domain or construct?		Item	Item fit with domain or construct?		Wording of item?		Suggested revisions to item; or indicate if item is to be discarded (or other notes about the item, domain, or construct).
		No	Yes		Poor	Good	Poor	Good	
(V) Behavioral beliefs: Perceived consequen-ces of engaging with science	(V.c) Beliefs about the relevance and utility of science: (i) at the societal level (Items 59–63)			59. Science helps people everywhere					
				60. We have a better world to live in because of science					
				61. Scientific discoveries do more harm than good					
				62. Scientific work is useful only to scientists					
				63. Most people should understand science because it affects their lives					
				Use the rows below to insert additional items if deemed necessary					
	(ii) at the personal level (Items 64–74)			64. What I learn in science classes is useful in my everyday life					
				65. Science is useful in helping solve everyday like problems					
				66. Science can help me to better understand the world					
				67. Science will help me understand the world around me					
				68. Science has nothing to do with my life outside of school					
				69. Knowing science can help me to make better choices regarding my health					
				70. Knowledge of science helps me protect the environment					
				71. Science can help me make better decisions about what I buy					
				72. It is important to know science in order to get a good job					
				73. Science classes will help prepare me for college					
				74. Learning science is not important for my future success					
				Use the rows below to insert additional items if deemed necessary					

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*Note: The packet provide to the advisory board had three attached appendices.

Item origins and modifications (similar to Appendix A)

Adaptation of TRAPB model (see Table 1)

ASSAS Domains and Constructs (Table 2, attached)

Table B.1 *ASSAS Domains and Constructs as These Relate to Elements of the Theories of Reasoned Action and Planned Behaviors (TRAPB)*

TRAPB component	Definition	Related ASSAS domain or construct	Related ASSAS sub-domain or sub-construct
Intention	Antecedent of actual engagement with the target behavior (Ajzen & Fishbein, 2005)	(I) Intention to pursue, interest in pursuing, science	(I.a) Additional or future studies in science (I.b) A career in science
Attitude toward the behavior	"A learned disposition to respond in a consistently favorable or unfavorable manner toward an attitude object [in this case, science]" (Fishbein &Ajzen, 1975, p. 6)	(II) Attitude toward different facets of science as it relates to student lives	(II.a) Attitude toward science (II.b) Attitude toward school science (II.c) Attitude toward science as leisure
Control beliefs ➔ Perceived behavioral control	"Beliefs concerning the presence or absence of factors that make performance of a behavior easier or more difficult . . . control beliefs lead to the perception that one has or does not have the capacity to carry out the behavior, referred to variously as self-efficacy and personal agency . . . or perceived behavioral control" (Ajzen & Fishbein, 2005, p. 193)	(III) Perceived self-efficacy and personal agency toward science learning	(III.a) Perceived ability toward learning science (III.b) Perceived efficacy of effort toward learning science
Normative beliefs ➔ Subjective norm	Beliefs "that deal with the likely approval or disapproval of a behavior by friends, family members . . . and, in their totality . . . lead to perceived social pressure or subjective norm to engage or not engage in the behavior" (Ajzen & Fishbein, 2005, p. 193)	(IV) Perceived approval or disapproval toward engagement with science	(IV.a) Perceived approval or disapproval by family members (IV.b) Perceived approval or disapproval by friends
Behavioral beliefs	Beliefs about "the likely consequences of a behavior . . . outcome expectancies . . . or costs and benefits . . . these beliefs and their associated evaluations are assumed to produce an overall positive or negative evaluation or attitude toward performing the behavior in question" (Ajzen & Fishbein, 2005, p. 193)	(V) Beliefs about the consequences associated with engagement with science, and beliefs about the benefits associated with science	(V.a) Beliefs about consequences associated with becoming a scientist (V.b) Beliefs about consequences associated with science learning (V.c) Beliefs about the relevance and utility of science: (i) at the societal level; (ii) at the personal level

Comments on the Theoretical Framework

If you have any comments about the theoretical framework underlying the ASSAS instrument or ways in which the ASSAS domains and constructs map onto the theoretical framework, please provide them in the space below:

APPENDIX C: Revised ASSASS Instrument (English)

ARABIC SPEAKING STUDENTS' ATTITUDES TOWARD SCIENCE SURVEY (ASSASS)

QATARI STUDENTS' INTEREST IN, AND ATTITUDES TOWARD, SCIENCE (QIAS)

1. Date		2. School name						
3. Grade level	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9	4. Section (if any):
5. [redacted]								
6. Age		7. Gender	☐ Male	☐ Female				
8. Nationality	☐ Qatari	☐ Non-Qatari Arab	☐ Other (specify):					

9. How far in school did your father go?	10. How far in school did your mother go?
☐ He did not finish high school	☐ She did not finish high school
☐ He finished high school	☐ She finished high school
☐ He got a vocational diploma	☐ She got a vocational diploma
☐ He graduated from a university	☐ She graduated from a university
☐ I do not know	☐ I do not know

11. Individuals who work for my family at home include (check all that apply **and** specify the number of each)						
☐ Maid: ___	☐ Nanny: ___	☐ Driver: ___	☐ Gardner: ___	☐ Private teacher: ___	☐ Cook: ___	☐ None

12. My family owns (check all that apply inside or outside Qatar)						
☐ Apartment	☐ One-level villa	☐ Large villa	☐ Vacation home	☐ Yacht	☐ Chalet	☐ Farm

13. My family owns (check all that apply **and** specify the number of each)			14. Do you use a computer at home?	
☐ Car/Saloon: _________	☐ SUV: _________	☐ Pickup/Truck: _________	☐ Yes	☐ No

15. How many books are there at your home?	☐ Few (0–10 books)	☐ One bookshelf (11–25 books)	☐ One bookcase (26–100 books)	☐ Several bookcases (more than 100 books)

16. How often do you talk about things you learn at school with someone in your family?			
☐ Never	☐ Once every few weeks	☐ Two or three times a week	☐ Every day

17. At school, I study science in:	☐ Arabic	☐ English	☐ Other (specify):
18. I **prefer** to learn science at school in:	☐ Arabic	☐ English	☐ Other (specify):

19. My science grades at school are:	☐ Not so good	☐ Average	☐ Good	☐ Very good	☐ Excellent

Instructions

There are no "right" or "wrong" answers to the following questions. We are simply interested in your feelings about a number of issues related to science and science learning.

- Indicate the extent to which you agree or disagree with each the following statements.
- Place a check mark (✓) or an (✗) on the response that best represents your answer.
- Check **only one answer** for each question.

– If you "Strongly disagree" with a statement, then you should check:

Strongly disagree	Disagree	Not sure	Agree	Strongly agree
✓	○	○	○	○

– If you "Disagree" with a statement, then you should check:

Strongly disagree	Disagree	Not sure	Agree	Strongly agree
○	✓	○	○	○

– If you are "Not sure" whether you agree or disagree with a statement, then you should check:

Strongly disagree	Disagree	Not sure	Agree	Strongly agree
○	○	✓	○	○

– If you "Agree" with a statement, then you should check:

Strongly disagree	Disagree	Not sure	Agree	Strongly agree
○	○	○	✓	○

– If you "Strongly agree" with a statement, then you check:

Strongly disagree	Disagree	Not sure	Agree	Strongly agree
○	○	○	○	✓

	Strongly disagree	Disagree	Not sure	Agree	Strongly agree
1. I enjoy science	○	○	○	○	○
2. Learning science is not important for my future success	○	○	○	○	○
3. We do a lot of interesting activities in science class	○	○	○	○	○
4. Most people should understand science because it affects their lives	○	○	○	○	○
5. I will study science if I get into a university	○	○	○	○	○
6. I am sure I can do well on science tests	○	○	○	○	○
7. Scientific discoveries do more harm than good	○	○	○	○	○
8. I usually give up when I do not understand a science concept	○	○	○	○	○
9. Science is one of the most interesting school subjects	○	○	○	○	○
10. Teachers encourage me to understand concepts in science classes	○	○	○	○	○
11. Science classes will help prepare me for university	○	○	○	○	○
12. Science is easy for me	○	○	○	○	○
13. My science teachers are very good	○	○	○	○	○
14. I will not pursue a science-related career in the future	○	○	○	○	○
15. I like to watch TV programs about science	○	○	○	○	○
16. I cannot understand science even if I try hard	○	○	○	○	○
17. Science is useful in solving everyday life problems	○	○	○	○	○
18. I will become a scientist in the future	○	○	○	○	○
19. I look forward to science activities in class	○	○	○	○	○
20. A job as a scientist would be boring	○	○	○	○	○
21. I like to learn more about science	○	○	○	○	○
22. I really enjoy science lessons	○	○	○	○	○
23. I will continue studying science after I leave school	○	○	○	○	○
24. My family encourages my interest in science	○	○	○	○	○
25. I am confident that I can understand science	○	○	○	○	○
26. We live in a better world because of science	○	○	○	○	○

	Strongly disagree	Disagree	Not sure	Agree	Strongly agree
27. I would enjoy working in a science-related career	○	○	○	○	○
28. I will miss studying science when I leave school	○	○	○	○	○
29. My friends like science	○	○	○	○	○
30. Knowing science can help me make better choices about my health	○	○	○	○	○
31. My family encourages me to have a science-related career	○	○	○	○	○
32. I really like science	○	○	○	○	○
33. If I could choose, I would not take any more science in school	○	○	○	○	○
34. Knowledge of science helps me protect the environment	○	○	○	○	○
35. It helps me to learn science in the same language I use at home	○	○	○	○	○
36. Scientific work is only useful to scientists	○	○	○	○	○
37. Science will help me understand the world around me	○	○	○	○	○
38. My friends do well in science	○	○	○	○	○
39. If I work hard enough, I can learn difficult science concepts	○	○	○	○	○
40. I will take additional science courses in the future	○	○	○	○	○
41. Science lessons are a waste of time	○	○	○	○	○
42. Scientists do not have enough time for fun	○	○	○	○	○
43. People with science-related careers have a normal family life	○	○	○	○	○
44. I do not like science	○	○	○	○	○
45. My science teachers motivate me to learn science	○	○	○	○	○

THANK YOU FOR COMPLETING THIS SURVEY